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ERRATUM: Appendix, FREE WORLD SULPHUR SUPPLIES 1953:
Please read Fig. IV for Fig. V and
Fig. V for Fig. IV.

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# F O R E W O R D

The next issue of the Bulletin will be published under the name of the British Sulphur Corporation Ltd., which company will assume the functions of the executive office of the Sulphur Exploration Syndicate, as from 1st February, 1955. The change is being made partly for administrative reasons, and partly to provide the necessary financial backing for a continuance of the activities of the Sulphur Exploration Syndicate, under the same management. As from 1st February, 1955, the offices of the Corporation will be at 4, Grafton Street, London, W.1.

The objects of the Corporation are similar to those of the Syndicate, though there is no longer the same need to emphasise the exploratory activities. In order to keep abreast of new developments, the Corporation will maintain its interest in new sulphur producing projects and processes which, when desirable, would be publicised in the Quarterly Bulletin. In appropriate cases, the Corporation may, either directly or indirectly, consider financial participation in a sulphur producing project or extending assistance in the disposal of sulphur so arising.

From the investigations of the past three years, and with the aid of information obtained from a world-wide chain of contacts in industry, trade and government departments, a unique and comprehensive record of the world sulphur industry has been built up. Through the medium of the Quarterly Bulletin much of this information has been passed on to all concerned with sulphur.

It is the British Sulphur Corporation's intention to keep this fund of sulphur intelligence up to date, and to continue to publish the Quarterly Bulletin, which has now established itself, in world circles, as an authoritative and reliable source of impartial up-to-date information.

The Corporation look forward to maintaining this useful service and to increasing its scope and value with the continued support of subscribers and sources of information.

December, 1954.

# R E V I E W

In the SURVEY OF WORLD SULPHUR SUPPLIES the trend of developments over the next 10 - 12 years is examined. Based on the present-day price of Frasch sulphur it appears probable that during this period the decline of United States land-based Frasch sulphur production will at best be made good by increasing production in Mexico. The anticipated increase of world requirements between 1956 - 1965 of about 4.2 million tons of sulphur in all forms, is expected to have to be met from sources other than Frasch sulphur. Recovery from natural sour gas and the application of modern refining processes to native sulphur ores are likely to provide the major proportion of additional requirements, while an increasingly important contribution may be expected from sulphur recovery from industrial gases which may be pursued beyond its economic limits in the light of air pollution and strategic considerations. The availability of ample low-cost elemental sulphur supplies in the immediate future may reverse the trend of the increased pyrites use of recent years, and this may hasten the development of economic means of dissociating sulphur and metal values in pyritic ores. With adequate investment and economic stability in the potential producing countries, a major increase in the price level of sulphur may be avoided.

The Commonwealth territories reviewed in this issue are CENTRAL AFRICAN FEDERATION AND BRITISH EAST AFRICA. In the great and varied mineral wealth of these territories deposits of sulphurous raw materials are lacking. The North Rhodesian copper belt provides the most significant source, where sulphurous stack gases result from the smelting of copper and zinc. Only a fraction is at present recovered in the form of acid and the bulk of the potentially recoverable sulphur content of over 150,000 tons per annum will continue to be exhausted to the atmosphere pending the growth of consumer industries which would warrant greater utilisation.

The sulphur industry of PORTUGAL is based on rich pyrites deposits which have been exploited for nearly 100 years, providing, in this time, over 10 million tons of

sulphur in pyrites, of which about 85% have been supplied to the acid industries of Western Europe and North Africa. The annual productive capacity of the various mines is estimated to total 400,000 tons of sulphur in pyrites. The promising results of recent geophysical surveys may lead to increased production, which, as the result of Government export controls aimed at preserving reserves for anticipated domestic needs, had in the past two years been cut back to about 300,000 tons of sulphur in pyrites. Present-day domestic requirements total about 95,000 tons of sulphur, including about 20,000 tons in an elemental form, most of which results from the treatment of pyrites by the Orkla process at the San Domingos mine of Mason & Barry Limited. The expected expansion of sulphur use, notably for fertiliser manufacture, may, it is thought in some quarters, double domestic requirements in the next five years.

In the U.S.A., production during the third quarter, of native and recovered sulphur, totalled 1,462,736 tons, and production during the first 9 months of 1954 - over 4.38 million tons - was the highest on record, exceeding that of the corresponding period of 1953 by more than 5%. Low domestic demand, which only started to improve towards the end of the third quarter, was more than compensated by high exports, and apparent sales totalled 1,465,085 tons. Apparent sales for the first 9 months of nearly 4.19 million tons exceeded those for the same period in 1953 by about ¾%, mainly on account of the highest export total on record of 1.2 million tons.

In the sulphur industry in ITALY the critical situation persists. As the result of subsidised production increasing, and the inability to export, the country's stocks are reported to exceed 300,000 tons. Industry is looking to the Government, whose attitude concerning the future level of production, prices and the disposal of accumulated stocks may be made public in January, when the presentation of appropriate Bills in the Italian House of Representatives is expected.

In the UNITED KINGDOM consumption of sulphur in all forms during the third quarter amounted to about 201,000 tons, about 11% more than during the corresponding

quarter of 1953. Elemental sulphur consumption totalled 88,800 tons, 2½% less than during the second quarter, but owing to apparently greater reductions in the use of other raw materials for acid making, the proportion of brimstone acid rose ¾% to 35¾%. Acid output totalled 489,600 tons, 8¾% more than during the corresponding period of 1953. After continuing to decline seasonally in July and August, acid consumption in September was the second highest monthly total on record; compared with the corresponding period in 1953, acid consumption during the third quarter, 1954, amounting to 488,500 tons, was 6½% greater, with most consumer industries showing increased requirements. The only major decrease was recorded in the use for superphosphate manufacture. The progressive expansion of acid requirements may temporarily continue to strengthen the position of brimstone as a raw material for acid making. The full impact of new anhydrite acid supplies in the autumn is likely to reverse this trend, even if regulations controlling its use were then removed.

The review of the three new ANHYDRITE ACID PROJECTS summarises the progress to date of this important section of the United Kingdom acid industry, which in the autumn of 1955 is expected to contribute at the annual rate of 300,000 tons to the acid requirements of the country, and which, together with the existing plant at Billingham, may then account for 19% of U.K. acid supplies.

The REFINING PROCESS developed by Scientific Design Company of New York from the earlier Nagelvoort process, is based on the use of carbon disulphide as a solvent, and in this field it is believed to be, at present, the only "continuous" process. It is stated to be suitable for ores with a sulphur content as low as 10% and to give high recovery at costs permitting this form of sulphur production to compete with Frasch sulphur.

World prices of sulphur have continued stable although the steep rise of sea freights in recent months has caused an increase in consumers' costs which, in the U.K. and Western Europe, is estimated to be in the region of 6 - 7%, The record level of elemental sulphur production in U.S.A. in 1954, estimated at 5.8 million tons,

more than satisfied all export demands which exceeded 1½ million tons, the highest on record, as well as domestic needs which, as the result of the quickening of the U.S. economy during the autumn, showed an increase on earlier months of the year. The critical situation of the sulphur industry in Italy remains unsolved. Chilean suppliers, in spite of low prices, are having difficulties in finding markets. The available Frasch sulphur production in the U.S.A. and Mexico is likely to exceed world demand in 1955, more so as world supplies of recovered sulphur show a further improvement and increased tonnages of low cost native sulphur may also seek markets. Competitive supplies available to expanding markets, notably as regards "regular" sulphur needs, promise to make 1955 a satisfactory year.

Note: By courtesy of the Freeport Sulphur Company, their Survey of Free World Sulphur Supplies in 1953 is included at the end of this Bulletin.

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SULPHUR EXPLORATION SYNDICATE

## Survey of World Sulphur Supplies

(September 1954)

### General

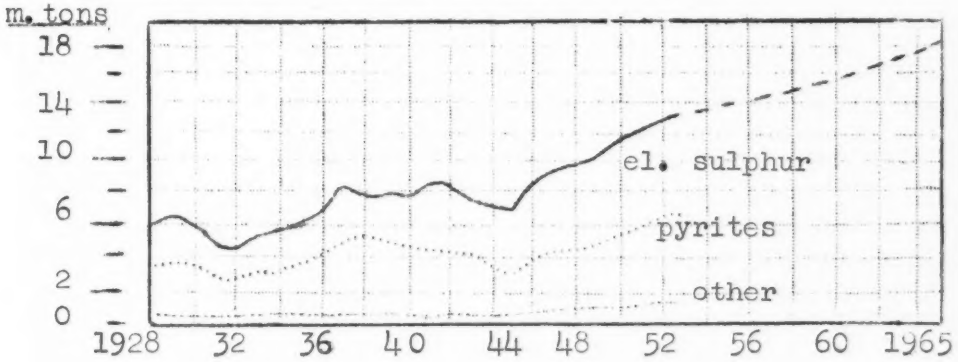
The successful exploitation of new domes by the Frasch process since mid-1953 has progressively increased available world supplies of cheap sulphur. Whereas in the U.S.A. the peak of this development surge appears to have been passed when Garden Island Bay came on full production in January, 1954, the Mexican developments, provided they fulfil their promoters' expectations, will not exert their main impact until early in 1955. Broadly speaking, these developments should, under the present pattern of world consumption, ensure that, for at least 18 months, but possibly up to three years, supplies of cheap sulphur will be adequate to meet demand and that market conditions in this period will tend to be competitive.

In this review it is intended to examine the probable trend of world production of sulphur in its various forms over a period of, say, 10 - 12 years, in an attempt to establish whether, in the light of rising world consumption of sulphur, the present pattern of production and consumption is likely to undergo significant changes, and whether or not Frasch sulphur production can be expected to maintain its hitherto unrivalled position as low-cost producer.

### World Production and Consumption

During the five-year period 1948 - 1953, world production and consumption of sulphur in all forms increased 31½% or at an annual rate of 5.6%. This was more than double the expansion rate of earlier years as between 1928 - 1938 the increase was 28% (2.6%p.a.) and between 1938 - 1948, 24% (2.3% p.a.). Over the entire 25 year period up to 1953, the average annual increase amounted to just over 3%. On the assumption that the expansion of consumption will continue at this rate -

which incidentally corresponds to the estimate in the Paley Report - it would appear that total world sulphur requirements will be as follows:-




In 1953 the supply position was balanced at 12.8 million tons sulphur, while production of the various sulphurous raw materials was as follows (in thousand tons):-

| | | |
|---|---|---|
| Frasch sulphur | 5,155 | |
| Recovered sulphur | 690 | |
| Native sulphur | 505 | 6,350 (49½%) |
| Sulphur in pyrites | | 4,850 (38%) |
| Sulphur in other forms | | 1,600 (12½%) |
| | | 12.8 million |

According to promoters' statements, total new sulphur capacity in all forms at present under construction is about 3 million tons, with a further 2.1 million tons under consideration. Of these projects it is estimated that the following will be completed by 1956:-

| | |
|---|---|
| Frasch sulphur | 575,000 |
| Native sulphur | 25,000 |
| Recovered sulphur | 130,000 |
| Sulphur in pyrites | 225,000 |
| Sulphur in other forms | 145,000 |
| | 1,100,000 |

To this total should be added the capacities of projects that started in 1953, but which did not exert their full impact on that year's total output:-

| | |
|---|---|
| Frasch | 670,000 |
| Native | 30,000 |
| Recovered | 130,000 |
| Pryites | 30,000 |
| Other forms | 40,000 |
| | 900,000 |

Wastage up to 1956 is estimated as follows:-

| | | |
|---|---|---|
| Frasch | 250,000 | (Not compensated |
| Native | 100,000 | by increased |
| Pyrites | 130,000 | utilisation of other |
| Other forms | 20,000 | dome capacities) |
| | 500,000 | |

Thus the supply position in 1956 is expected to be as follows:-

| | | |
|---|---|---|
| Frasch sulphur | 6,150 | |
| Recovered sulphur | 950 | |
| Native sulphur | 460 | 7,560 (53%) |
| Sulphur in pyrites | | 4,975 (34¾%) |
| Sulphur in other forms | | 1,765 (12¼%) |
| | | 14.3 million |

U.S. Frasch sulphur supplies are expected to total 5.6 million tons and those in Mexico 550,000 tons. Allowing for increased elemental sulphur availabilities from other sources, mainly recovery, the two countries' domestic markets are expected to take up 4¼ million tons Frasch sulphur, leaving an export surplus of 1.9 million tons. In 1953 Frasch sulphur exports wholly of U.S. origin amounted to 1¼ million tons. Under conditions of plentiful supply, it is estimated that foreign demand would rise to at least 1.8 million tons.

It is probable that, as the result of such conditions, which, in 1955, are likely to result in the largest margin between supply and demand, when keen competition in export markets can be expected, the use of pyrites and the utilisation of other expensive raw materials, wherever they are high cost substitutes, may not expand correspondingly. This is particularly the case in countries where conversion schemes are still in progress, e.g. Australia, and where competition in acid and fertiliser supplies is keenest, such as U.S.A. and Western Europe.

In examining each source of sulphur supply the present-day price of Frasch sulphur has been taken as a datum level in order to assess whether and how this will permit adequate alimentation of world sulphur demand from the various sources of sulphur.

Frasch Sulphur

Production Costs

Although in the inter-war years production costs of Frasch sulphur were already lower than those of native or recovered (Orkla) sulphur producers, the difference was small enough to have brought about marketing agreements between American and Italian and Norwegian producers, and to have attached considerable nuisance value to other producers who enjoyed geographical advantages in certain markets.

The spectacular growth of the U.S. domestic market during the war enabled Frasch sulphur producers to keep down production costs during the immediate post-war years, mainly on account of the reduced incidence of overhead costs and amortisation whereas elsewhere producers of mined sulphur working with obsolete plant and methods were faced with steadily mounting operating and labour costs. With the installation of new plants and the exploitation of new domes, of which Jefferson Lake Sulphur Company's Long Point was the first in 1946, followed by Texas Gulf Sulphur Company s Moss Bluff and Spindletop, Jefferson Lake's Starks, and finally Freeport Sulphur Company's four-dome programme, higher capital and labour costs exerted their influence which were reflected by price increases in 1948, 1950 and

again, after the cessation of price control, in spring, 1953. These successive increases finally led to the establishment of 1st January 1954 of the domestic price of $28 per long ton f.o.b. by three of the four principal producers, Texas Gulf Sulphur, Freeport Sulphur and Duval Sulphur and Potash. This new price showed an increase of $7 and $9 respectively (33⅓% and 45% over the prices ruling in 1948.

In an attempt to assess the net increase in sulphur prices, a comparison has been made with the general level of U.S. prices of fertiliser materials which are thought to be the nearest comparable commodity group. These prices had increased in the same period by 10.6%, and such an increase applied to the 1948 price of sulphur would represent about $1.90 and $2.30 respectively. Again, if the 1948 and 1953 prices of sulphur are compared in terms of dollar purchasing power which had been reduced in this period by 8.7%, the net price advance is similar at $4.60 and $6.30, or an increase of about 23% and 29% respectively. The ex-mine price of sulphur (now $26.50) shows the largest increase at about 33% net. Compared with 1950 current prices show a net increase of about 10%. The Paley Report estimated that an increase of 25% on the 1950 price of sulphur would add 20 - 40 million tons to U.S. reserves of native sulphur estimated at 50 - 100 million tons.

The most important effect of the new price level was the extension of life of some of the old domes which had approached their limit of profitability. Apart from the additional capacity thus made available to the established companies, it also encouraged newcomers who started operations at some domes which had been abandoned and not considered profitable many years ago. An examination of the balance sheets of Texas Gulf Sulphur, Freeport Sulphur and Jefferson Lake Sulphur companies permits the calculation of approximate average operating costs. In the case of the two last named companies, their other interests tend to detract from the accuracy of these calculations.

| Per ton | Texas Gulf $ | Freeport $ | Jefferson Lake $ |
|---|---|---|---|
| Total costs 1952 | 11.71 | 17.49 | 12.48 |
| Total costs 1953 | 13.52 | 21.45 | 16.43 |
| Operating costs 1952 | 8.77 | 14.96 | 10.52 |
| Operating costs 1953 | 10.23 | 18.51 | 13.40 |
| Amortisation and depreciation 1952 | 0.85 | 1.48 | 0.71 |
| - do - 1953 | 0.93 | 1.88 | 0.70 |

Whereas the lowest cost producers, such as Texas Gulpg Sulphur Boling Dome, may still permit production costs not appreciably in excess of $6 - $7 per ton of sulphur, operating costs at new installations appear to be much higher, and some producers now consider the margin between costs and sales price to be narrow. This view is undoubtedly related to the U.S. domestic price of $28, and it should also be interpreted in the light of earlier sulphur earning ratios which generally exceeded 100%. The trend of average costs indicated above tends to confirm the impression that the cost of new Frasch sulphur is in excess of $20 per ton, and in some instances may be as high as $25. There is little doubt that new Frasch sulphur projects such as Freeport's Chacahoula or Texas Gulf's Lake Bullicamp will involve operating costs in or near the above cost bracket.

In the case of off-shore domes with capital costs estimated two or three times greater than those on land, it is considered doubtful whether production even at the rate of 2,000 tons per day would keep costs below today's price level.

The effective f.o.b. price range of U.S. sulphur today is $26.50 - $33; taking into account known discounts for off-colour qualities, and that the bulk of U.S. Frasch sulphur exports is effected at $29.50 - $30 f.o.b. It is considered that in the imminent competitive period

established prices are not likely to be altered, with the possible exception of Jefferson Lake, who may abandon their price basis of $29.50 (domestic) and $33 (export) - although in specific instances the existing discounts are likely to be increased, or new ones devised in order to meet competition of Mexican sulphur in certain markets.

It is thought unlikely that Mexican producers will be able, even if they wished to do so, to undercut appreciably U.S. prices, in view of their considerable royalty commitments and tax obligations. In this connection, it is thought that a floor price of about $26 - $27 per ton f.o.b. Mexican ports may temporarily be reached, but as increasing Mexican supplies coincide with decreasing export availability of U.S. sulphur, prices are likely to settle at current levels.

Reverting to the question of rising operating costs, it is evident that the difficulties of access which characterise the majority of the latest developments in the U.S.A. are a notable adverse factor, although perhaps the most telling in the case of all long-established domes is the rising water requirement and the incidence of new well drilling. There are at present 14 operational domes in the U.S., of which five have been producing for more than fifteen years. Only two≠ new domes are known to be under development, both comparatively small. Of the old domes, Hoskins Mound is on the point of ceasing production, and two other domes' yields are reported to be falling off. In view of the comparatively small size of these two domes, cessation of output would not cause a notable disturbance of the sulphur market, particularly as this is bound to be preceded by two or three years' declining output. According to authoritative information "no decisive change" of output is anticipated at Boling and Grande Ecaille domes.

The discovery and development of new major sulphur domes is improbable, as the 230 known salt domes on the U.S. mainland, of which less than 10% prove to be exploitable from a sulphur point of view, appear to have been fully explored. The exploitation of off-shore domes appears to be precluded at present price levels,

≠ Since the compilation of this review, investigations at five other small domes are reported.

although the development by Humble Oil Company may give an indication of probable trends.

The development of Frasch sulphur in Mexico is at present limited to three domes with a combined rated annual capacity of $\frac{3}{4}$ million tons, and with combined reserves of 35 million tons sulphur. Exploration by Texas Gulf Sulphur and Texas International Sulphur may add to this potential, and, given success at the domes at present under development, their capacities are to be expanded to about double their present size. The determining factors in the Mexican Frasch sulphur developments are undoubtedly the individual producers' ability during the next two or three years to compete with American sulphur in export markets, and to establish consumers' confidence by overt material and financial proof of the soundness of their production activities. If successful, the orbits of interest of American and Mexican producers in home and export markets will inevitably overlap.

Native Sulphur

The various aspects contributing to the present-day marginal nature of native sulphur production are too well known to warrant further comment. With the exception of small tonnages representing about 6% of the total output of $\frac{1}{2}$ million tons, native sulphur does not enter export markets due to its inability to compete. At present only the inflationary state of their countries' economies permit these high cost producers to find an outlet in their respective home markets. The initiative in the introduction of modern rational mining and refining methods is only to a limited extent in producers' hands, who, although aware for the need for drastic measures, have been hampered by lack of domestic capital and the reluctance of foreign investors. In this respect most of the projects carried out are inspired by plant makers and process lessees whose activities in research, stimulated by the sulphur crisis, are now beginning to come to fruition.

The first of the modern refining plants are being tested under practical working conditions, and whereas

all are designed to permit sulphur production at a cost that would enable the product to compete with Frasch sulphur the accuracy of these cost and performance forecasts have yet to be proved. Of the variety of processes based on flotation, distillation or filtering, none has yet emerged as showing outstanding advantages. Nor is this likely as in the case of native sulphur specific processes may be best suited to certain types of ore. It is, therefore, impractical to compare production costs, more so as subsidiary costs such as transport in the case of Chile, labour in Italy, affect overall costs in different ways. Discounting cost estimates based on too favourable premises, it would appear that promoters have expectations of achieving f.o.b. costs (including amortisation) in the region of $15 - $25 per ton of sulphur.

In the immediate future the relative importance of native sulphur is expected to deteriorate further with an inevitable reduction of Italian, Chilean and Japanese high cost productions. At the same time it might be noted that the number of new developments is on the increase, and although the majority are designed to serve specific users in home or export markets they provide an important yardstick pointing towards the feasibility of expansion in this field. The anticipated competitive period between U.S. and Mexican Frasch producers will tend to keep native sulphur production in a marginal position, but there is little doubt that even small tonnages coming on to the world market from such new sources that have provided proof of their technical soundness and financial viability, will tend to keep prices down. The emergence of native sulphur in competition with Frasch sulphur is not considered likely before the start of the decline of U.S. production, as the economic instability of the countries holding the largest reserves is not likely to attract significant investment while markets are highly competitive.

Recovered sulphur

Outside the U.S.A., with the exception of negligible tonnages which become available as the result of seasonal fluctuations in consumer industries, recovered sulphur

does not enter export markets. The output in the U.S. today provides about 9% of domestic needs and it is increasing. As a supplementary form of supply to Frasch sulphur its influence on world markets is indirect. This situation may be completely reversed by large scale recovery from natural gas, notably in Canada but possibly also in the Middle East. The construction of a trans-Canada pipe-line is agreed and with gas exports authorised by the Alberta Government, it is probable that development of this valuable source of energy and raw material for the chemical industry may be well uner way by 1956, and completed by 1958. From the point of view of sulphur the deciding factor is transport. About 18 months ago, Canadian Railways reduced the freight rates on Alberta recovered sulphur by about 60% in order to enable producers to dispose of their current, albeit small, output. At present rail rates this output is competitive with imported U.S.A. material within an approximate radius of 800 miles from Calgary. The recovery of sulphur in conjunction with the prerequisite cleaning of the vast volume of natural sour gas that will be required to feed the pipe-line, is no longer in doubt and will result in a manifold increase in the present level of recovered sulphur production in Alberta. The remunerative disposal to more distant domestic and to export consuming centres at current world price levels would demand a further lowering of rail tariffs. At the same time it is thought unlikely that such special tariffs, if introduced, would reduce the price of Alberta recovered sulphur appreciably below corresponding Frasch sulphur prices. In consequence, any competitive position that native sulphur may be able to establish in relation to Frasch sulphur would equally affect this source of supply.

The cost of sulphur recovery from natural gas is reported to vary between $2 - $6 per ton sulphur according to the concentration of hydrogen sulphide present.

+ 40 tons sulphur is recoverable per one million cubic feet of hydrogen sulphide which is contained in Canadian natural gas at the rate of 4% - 9%.

Capital costs and the expectation of life of known installations vary considerably, and amortisation and other expenses range up to $10 per ton. The sales price of recovered sulphur in Canada is, at present, $20 ex works, but in view of excessive transport costs to consuming centres, these costs are only a subsidiary factor in the assessment of this source of supply.

The large scale exploitation of the vast gas reserves of the Middle East is unlikely to occur within the next ten years, with the exception of small projects in Iraq, in view of the absence of major industrial gas users. The construction of a gas pipe-line from the Middle East across Europe has been mooted, but such a project is, under prevailing political conditions, of little more than theoretical value. The recent developments in the field of natural gas refrigeration and its movement in liquid form open up significant possibilities, and these, if realised, may well permit large scale recovery at competitive cost.

Pyrites

Of the current world pyrites production about two-thirds is consumed in the countries of origin, and European acid makers consume the bulk of pyrites entering into export markets. The increasing production costs of pyrites, as such, jeopardise their future and already by-product pyrites, where the principal cost element is carried by the non-ferrous or precious metal, are gaining in significance.

The increased availabilities of Frasch sulphur and the potentialities of native and recovered sulphur will tend to force pyrites from their present artificially safe position into one of competition. A combination of favourable geographical location, established roasting plant and accessible cinder disposal facilities attract pyrites, but the absence of any or all of these factors under normal conditions of brimstone supply at current price levels mitigates against preferential expansion of pyrites roasting facilities.

The future of pyrites, and particularly by-product pyrites, is thought to lie not in their direct use for acid making, but as raw materials to be subjected to mineral separation. Research work in this field is progressing, but there is, so far, no indication that either the Canadian process of retort distillation at high pressure, or the German Duisberger Kupferhütte process may become economically viable within the period under review.

Sulphur in Other Forms

At present these supplies account for about 12½% of world sulphur production, and whereas increased utilisation may be expected within the period under review, it is improbable that this will significantly enhance their importance in relation to other sources of supply. Increasing activity may be expected in connection with recovery of sulphur and production of by-product acid from industrial or smelter gases, which is likely to be intensified as the opposition to air-pollution in civilised countries increases, so that the cost element in the case of treatment of an increasing volume of industrial gases is not likely to remain the final criterion. In the case of sulphates, however, apart from strategic consideration similar limitations as obtain with pyrites are likely to govern the extension of their use for acid production, although direct employment for ammonium sulphate production should not be so affected.

Conclusion

Between 1956 - 65 world sulphur requirements are expected to rise by about 4.2 million tons. During this period the anticipated decline of U.S. land-based Frasch sulphur production will, at best, be made good by increasing Mexican output if realised. Complete cessation of output at either Boling or Grande Ecaille domes would, however, upset the chances of achieving this balance. Consequently, if the recurrence of a sulphur shortage and a further price rise are to be avoided, the entire additional requirements will have to accrue from other sources. The development of off-shore Frasch sulphur capacity is not thought to provide an alternative source of supply unless

a rise of current sulphur prices is accepted.

The new mining and refining techniques now under development to achieve economic production of native sulphur and the potentialities of recovery of sulphur from natural gas can provide a means of augmenting low cost sulphur supply, so long as timely capital investment is forthcoming, bearing in mind that during the imminent period of ample low cost Frasch sulphur supplies the scope of native sulphur expansion will be circumscribed. The present-day capital requirements of a modern mining and refining installation of native sulphur are about £8 - £10 per ton year for units of 100,000 - 200,000 tons refined sulphur, and capital cost for sulphur recovery plants from natural gas are in the region of £10 per ton year for units up to 50,000 tons refined sulphur. This compares with a land-based Frasch sulphur installation of about £10 per ton year for a large installation like Garden Island Bay, or rising to about £15 per ton year for smaller units.

The availability of ample low cost sulphur supplies during the next two to three years is likely to reverse the recent trend of increased pyrites usage, notably where existing pyrites roasting plants may need replacement. The provision of sulphur burners alongside existing pyrites roasting plant may give major importers a desirable measure of flexibility, particularly where the divergence in cost between elemental sulphur and sulphur in pyrites permits rapid amortisation of such subsidiary units. A decisive drop in pyrites consumption may, however, only be expected if elemental sulphur production - native or recovered - can prove its ability to ensure continuity of adequate supply.

The use of sulphur in industrial gases will contributeute increasingly towards meeting domestic sulphur needs in highly industrialised countries, but more than a gradual increase within the period under review is improbable as no large scale economic process is as yet in sight. Anti-air pollution and strategic considerations may tend to expand this source beyond its economic scope.

Although temporary fluctuations in supply and demand of elemental sulphur are likely to be frequent in the period under review, due to probable time lags between the realisation of the need for and actual investment in new production capacity, it is thought improbable that a long period of seller's market will ever establish itself. It is, however, essential, particularly from the point of view of U.K. consumers collectively and severally, that the trend of Frasch sulphur costs in relation to available capacity is constantly reviewed so that, allowing for the necessary development period of an alternative source of supply, be it native or recovered sulphur, timely action may be taken.

## THE CENTRAL AFRICAN FEDERATION AND BRITISH EAST AFRICA

### GENERAL

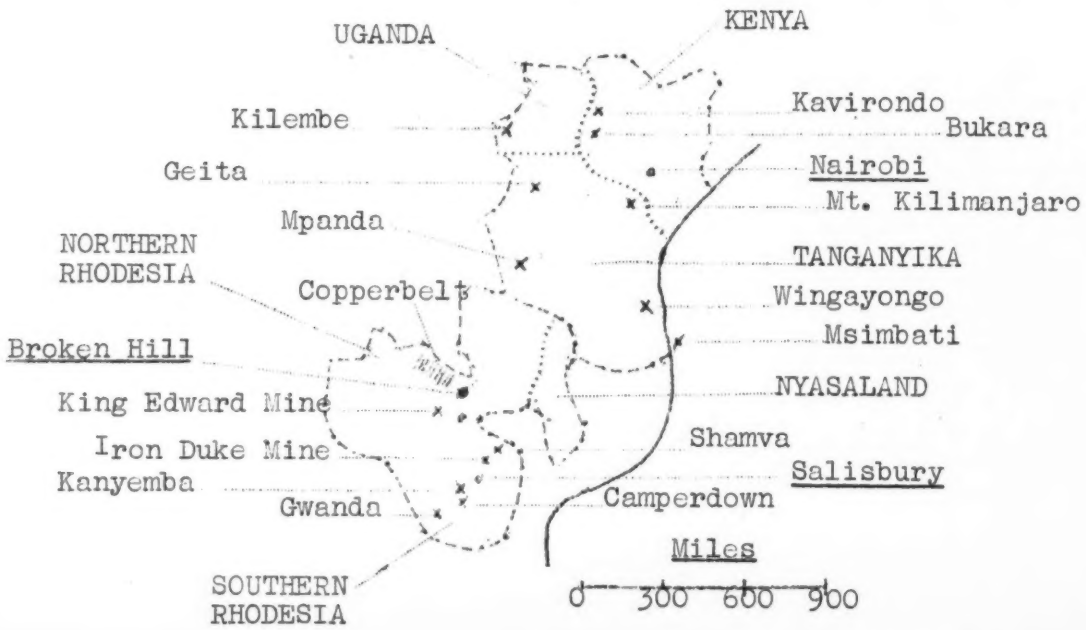
Although the vast territory encompassing Southern and Northern Rhodesia, Nyasaland, Tanganyika, Kenya and Uganda is favoured by rich deposits of a wide range of metallic and non-metallic minerals, the occurrence of sulphur bearing raw materials is insignificant. There are a number of low grade pyrites deposits, notably in Southern Rhodesia, of which only one is at present exploited, and several auriferous sulphide deposits in Kenya and Tanganyika. The only major source of sulphur in the territories under review are the smelter gases arising in the course of metallurgical operations in the North Rhodesian copper belt. Only a fraction is recovered in the form of by-product sulphuric acid, most of which is used at source, and accounts for the bulk of sulphur consumed in the territories under review. Deposits of native sulphur are known to exist in Tanganyika, but these do not warrant exploitation, either due to their exceedingly low sulphur content or, in the case of the volcanic deposit on Mount Kilimanjaro, due to the limited tonnage available. The moderate

elemental sulphur requirements, amounting to a few hundred tons a year, are wholly met by imports, and the slow industrial development holds out little promise of an early significant growth of the sulphur industry.

DEPOSITS AND PRODUCTION

Native Sulphur

As the result of fumerole activities on Mount Kilimanjaro, a deposit of sulphur has accumulated in the ash pit of the Kibo, the most recent crater, at a height of more than 19,000 feet. The accumulation of sulphur is believed to have started in the early 1930's, and in the course of a detailed investigation in 1951 by members of the Colonial Geological Survey the tonnage of sulphur was estimated to total about 6,400 tons. The bulk of the sulphur appears to be deposited along the crater terraces, and to a lesser extent on the crater floor and scarp. In view of continued fumarole activity it is probable that the



quantity of sulphur may gradually increase, although the small tonnage involved, and difficulties of operating at that height, coupled with the problem of transportation, make it unlikely that this deposit will be exploited. It is estimated that under present conditions sulphur so obtained would cost in the region of £50 per ton at the nearest road-head.

Two sulphur impregnated sandstone deposits are known to exist in Tanganyika. They are Wingayongo, in the Utete district, and Msimbati, about 20 miles from Mikindani on the island of Ras Matundo. The possible exploitation of the latter deposit which contains about 6% sulphur was investigated by the African Industrial Research and Development Board in 1943. It was found that the material was amenable to flotation yielding a 97% S-product, but recovery was very low, only about 30%.

Pyrites

SOUTHERN RHODESIA. Of the pyrites deposits in Southern Rhodesia only one, the Iron Duke Mine, ~~owned by Rhodesia Broken Hill Development Ltd.~~, is at present being exploited. This mine is situated 8 miles from the Glendale Siding on the Salisbury - Shauma branch of the Rhodesia Railways. Glendale is about 50 miles from Salisbury.

The Company acquired the mine in 1933 as a source of pyrites for the manufacture of sulphuric acid to be used in their zinc leaching process. Initially, only oxidised zinc ores were leached but since 1946 zinc blende has been mined and roasted to calcine for leaching, and the roaster gases have taken the place of pyrites is a source of sulphur for acid manufacture. Iron Duke has, however, remained in operation supplying pyrites to the Copperbelt as a smelter flux, and has also supplied limited quantities to acid plants in the Union of South Africa. Since the end of the war, annual production has fluctuated between 13,000 tons and 20,000 tons of pyrites. In 1953, export demand caused production to be increased to over 40,000 tons.+

The orebody consists of a band of nearly solid pyrites some 20 to 35 feet wide, dipping steeply with the country rock.

+ For full details see Statistical Appendix

Towards the footwall, the pyrites are mixed with more or less vein quartz. The grade thus varies, but is nominally taken as 40% after sorting out a certain amount of quartz waste. The ore has been proved to extend to a depth of at least 1,000 feet, with a slightly diminished grade. Mining is now being carried out on the 325 foot level, through a small vertical shaft in the footwall. The mine is equipped to produce up to 5,000 short tons per month, and it is understood that, were a market available for the additional production, this could be stepped up without difficulty to 10,000 tons. At one time plans were in existence to raise production to 24,000 tons per month.

Other deposits are as follows:-

The Kanyemba Mine in the Hartley district. The reserves of this deposit are said to amount to several million tons - some estimates put the figure as high as 30 million tons - of pyritic ore with a sulphur content of 25 - 27%. The exploitation of this deposit was contemplated in 1952 when the owners were investigating the possibility of producing elemental sulphur by the Orkla process or by a process similar to the Noranda process. In view of the capital expenditure exceeding £2,000,000 involved, it was found that the cost of sulphur so produced would not be competitive in world markets and the project was abandoned.

Camperdown Mine at Selukwe. This mine closed in 1947, as the sulphide ore proved to be too low grade for economic exploitation.

Hampden Mine, near Gwanda, and the Shamva Mine. The concentrations of pyritic ore at these two mines are small and sporadic, and it is unlikely that either mine will be taken into production.

NORTHERN RHODESIA. The only known pyritic orebody of any consequence is that at the King Edward Mine, about 30 miles west of Lusaka in Northern Rhodesia, owned by Nchanga Consolidated Copper Mines Limited. The deposit consists of cupriferous pyrites in dolomite countryside with a width averaging about 20 feet at a depth of 300

feet. The sulphur content is only about 15%, and the ore would require beneficiation before it could be used as a source of sulphur.

KENYA. Nyanza Goldfields. A number of promising ore deposits at the Macalder - Nyanza mine, S. Kavirondo, have been partly developed. One ore deposit close to the shores of Lake Victoria near the Tanganyika territory has proved reserves of $\frac{3}{4}$ million tons carrying economic values of gold, silver, copper and zinc. ~~If smelted for the recovery of the metal contents, it is thought possible that sulphuric acid or sulphur would be recoverable from the smelter gases.~~

North Kavirondo. Two deposits where extensive gossans overlie veins rich in auriferous pyrite and pyrrhotite have been examined for their gold content but are not being worked.

At Bukara, 30 miles north east of Kisumu, a deposit of pyrites has been reported and its exploitation ~~is being~~ was once considered.

Kerebe Mines Limited. A substantial deposit of gold sulphide ore which would permit the production of 50 tons a month pyrite concentrate of 45% sulphur and 3 oz. per ton gold is of little interest from the point of view of sulphur as the concentrate is said to carry some 20% arsenic.

TANGANYIKA. Nyamakundi Prospect. This deposit is situated about 5 miles south west of Geita, and is considered to be the most promising in the territory. The reserves below the zone of oxidation are estimated at over 3,400 tons of ore per foot of depth containing 61½% pyrite and 0.8 dwt. per ton gold, and permitting the production of a pyrite concentrate of 50.7% sulphur.

Geita Goldmines. A number of small pockets of pyritic ore are known to exist in this area, and some quantities of pyritic tailings arise in the course of gold ore production, ~~which are, at present, being dumped.~~ These are dumped as Recovery is not considered economical.

Mpanda Mineral Field. Various metal sulphide ores produced from these deposits are exported in crude form for treatment at European refineries.

UGANDA. Kilembe Coppermines. The development of the large deposits of pyritic copper/cobalt ore is taking place. The smelting of the ore is expected to permit the by-product recovery of sulphuric acid from smelter gases. If this is realised it may further plans for the establishment of superphosphate manufacture using the indigenous phosphate rock of Tororo.

Sulphur from smelter gases

The treatment of copper and zinc sulphide ores originating from the vast mineral deposits of Northern Rhodesia result in the emission of gases which, if fully utilised, would permit the annual recovery of over 150,000 tons of sulphur. Though technically feasible the production costs are not economic, and in consequence only a fraction of these gases are utilised in the production of by-product acid required for copper and zinc ore leaching operations.

The inception of metallurgical operations on copper concentrates from the new Chibuluma mine of the Rhodesian Selection Trust will result in a further unutilised arising of sulphur in smelter gases. It is estimated that by the end of 1955, about 25 tons per day of sulphur in the form of 12% $SO_2$ in gases will be dissipated to the atmosphere from this source.

CONSUMPTION

Elemental Sulphur

The present consumption of elemental sulphur is estimated as follows:-

| | Tons p.a. |
|---|---|
| Southern Rhodesia | Up to 20 |
| Northern Rhodesia | 1 - 2 |
| Tanganyika | Up to 80 |
| Kenya | 300 - 400 |
| Uganda | 200 - 300 |

Most of this sulphur is used for agricultural purposes. Some is used for chemical manufacture by African Explosives and Chemical Industries (Rhodesia) Ltd., in Salisbury, Southern Rhodesia.

Pyrites

Since the discontinuation at Broken Hill of pyrites use for acid production, the consumption of pyrites in the territories under review is limited to their use as smelter flux, in order to lower the grade of copper matte produced. Most of the sulphur content is consequently dissipated in unutilised smelter gases.

Sulphuric acid

Production of sulphuric acid is confined to Northern Rhodesia, where there are two plants. The plant of the Rhodesia Broken Hill Development Company Limited produces 60% acid in a chamber plant, using gases from the roasting of zinc concentrate. The rated capacity is 1,800 short tons per month of acid (100% $H_2SO_4$). Gases from the smelter of the Rhokana Corporation at Nkana are used in a contact plant to make 92% acid. Rated capacity of the existing unit is 1,500 short tons per month of acid ($H_2SO_4$ 100%). A second unit is now under construction.

Most of the acid produced at these plants is used in the metallurgical processes of the various companies operating in the copper belt. At Broken Hill, the acid is used for leaching zinc and vanadium ores. On the Copperbelt, acid produced at Nkana is used chiefly for leaching copper oxide concentrates in the leaching plant at Nchanga, preparatory to the recovery of the copper electrolytically. Smaller quantities are used for make-up purposes in the copper refineries at Nkana and Mufulira, estimated at about 4,000 and 3,000 t.p.a. acid respectively, also in the electrolytic cobalt plant of the Rhokana Corporation, and for rare metal extraction.

The establishment by Roan Antelope Copper Company of a new refinery at Ndola in about 3 - 4 years time is expected to raise acid requirements by about 3,000 t.p.a.

## TRADE

### Elemental Sulphur

The small requirements of some 500 - 800 t.p.a. of refined sulphur are met by imports of various grades.

### Pyrites

In the absence of a local outlet in Southern Rhodesia for the pyrites output of the Iron Duke Mine, this is exported chiefly to Northern Rhodesia, and since 1951 also to acid plants in the Union of South Africa. As the result of the substantial increase in pyrites consumption in the Union, these exports have risen from about 6,000 tons to about 32,000 tons in 1953. Pyrites exports in 1953 were valued about £1. 10s. per short ton f.o.r. on deliveries to the Union, and £1 per short ton f.o.r. on deliveries to Northern Rhodesia. By the end of 1955, as the result of operations starting at the Chibuluma mine, the Selection Trust Group will no longer need to import pyrites for their metallurgical operations. The pyrites requirements at the Nkana and Nchanga smelters of the Anglo-American group of companies may then also be met from local sources.

### Sulphuric Acid

Southern Rhodesia imports annually about 500 tons of acid, almost exclusively from the Union of South Africa, and re-exports small quantities to Nyasaland and Northern Rhodesia. Up to 1952 Northern Rhodesia imported up to 1,200 tons per annum of acid from the Union, Southern Rhodesia and the Belgian Congo. In 1953 Northern Rhodesia became a net exporter following deliveries of over 2,200 tons of acid to the Belgian Congo.

## CONCLUSION

The dominant feature in the sulphur picture of these territories is the large sulphur potential which is, at present, going to waste in the course of metal smelting operations in the North Rhodesian copper belt. The mining companies concerned are very conscious of this problem

and have for many years endeavoured to find economic means of using this sulphur. In the immediate future, however, there is no prospect of a change in the present tacit acceptance that the acid production of the copper belt can serve only the comparatively small local needs. At the same time the gradual agricultural and industrial developments throughout this part of Africa may, within 10 - 15 years, sufficiently raise requirements of sulphuric acid that an extension of present by-product acid facilities will become justified.

## PORTUGAL

The sulphur industry of Portugal is based on the rich pyrites deposits forming the western end of the massive pyrite belt which extends across the Iberian peninsula. Although quantitatively smaller than those from neighbouring Spain, pyrites exports from Portugal represent an important source of sulphurous raw material supply to the acid industries of Western Europe and North Africa.

Regular production and shipments of pyrites date back to 1857, when Messrs. Mason and Barry of London started exploitation of the San Domingos mine. At the beginning of the present century several small mining enterprises were started, although regular operations by the other two major mines active today, namely, Aljustrel and Louzal, only date from about 1920. It is estimated that up to the present day over 10 million tons of sulphur in pyrites havebeen produced in Portugal, of which nearly 85% have been exported. Portugal lacks native sulphur deposits, but the establishment in 1934 of a plant to treat pyrites by the Orkla process has since provided the Portuguese economy with the bulk of its elemental sulphur requirements.

The gross production capacity of the various mines is estimated to amount to about 400,000tons of sulphur in pyrites. In 1953 production totalled about 300,000 tons, mainly as the result of a 25% reduction of exports compared with 1952, in which year pyrites output amounted to 355,000 tons of sulphur in pyrites, the highest level ever

recorded. Today's requirements of Portugal's sulphur using industries is estimated at about 95,000 tons of sulphur. Of this, about 20,000 tons is in elemental form, and the balance as pyrites consumed by the sulphuric acid industry, which is wholly based on the use of this raw material. Thus, allowing for the actual tonnage of pyrites consumed in elemental sulphur production, domestic needs account for about 35% of production, the balance being available for exports. The reduction of exports referred to above, although partly influenced by market conditions, was primarily attributable to the imposition by the Government of strict export controls. This decision was occasioned by the Government's desire to ensure that the pyrites reserves, which form one of the country's principal natural assets, are not depleted at too rapid a rate, and so jeopardise the availability of supplies which may be needed to meet increased requirements of the Portuguese sulphur using industry. In recent years, considerable expansion of home consumption has taken place, notably for the manufacture of sulphuric acid, fertilisers and textiles. The expansion plans of the fertiliser industry, the anticipated needs of the country's growing secondary industries, and the possible acid requirements for the processing of indigenous uranium ores have given rise to the estimate that within the next five years domestic usage may approach 200,000 tons a year sulphur in pyrites. In the past two years geophysical surveys of the country's pyrites reserves have been undertaken by the individual mining companies, and also under Government auspices, and initial results are said to be satisfactory. These surveys have already, in some instances, e.g. at Aljustrel, disclosed substantial additional reserves extending the life of some mines well beyond the ten year limit which pessimistic forecasts had predicted. While this may prevent an enforced reduction in output, it is thought unlikely that with increasing domestic requirements, the peak export levels of 1951 will be exceeded.

Pyrites Deposits and Production

The only sulphurous raw materials found in Portugal are iron and copper pyrites. Of the four principal deposits, viz., San Domingos, Aljustrel, Louzal and Serra de

Caveira, only the three first-named are, at present, being exploited. Other known deposits are small and do not permit economic extraction. There are also substantial deposits of arseno-pyrites containing up to 35% sulphur, but these are unsuitable as a sulphurous raw material, and are mined for their arsenic content only. In recent years, output has consisted almost exclusively of crude pyrites containing 45 - 49% sulphur, 0.9 - 1.2% copper, 42% iron, and metallic impurities such as lead, zinc and arsenic, and small quantities of gold and silver. The upper strata of the various deposits, now virtually exhausted, consisted of copper pyrites with contents up to 2½ - 3% copper. This material played a prominent part in the early years of pyrites mining when, by leaching on cementation heaps, it yielded copper precipitate and "washed pyrites", which then represented the bulk of saleable pyrites output.

The four above-named deposits are all owned by foreign domiciled companies, two Belgian and one British. They are:-

Messrs. Mason and Barry Ltd.

This company has operated continuously since 1857 the San Domingos mine, situated in the Baixo Alemtejo district. In ancient days it was worked by the Phoenicians and Romans, and the remaining slag heaps give proof that they smelted pyrites.

The San Domingos deposit is in the form of a large lens, which at the 47 metre level was about 600 metres long, 60 metres wide, and covering an area of about 197 acres. At first, the deposit was worked by open-cast mining, but this has been replaced by conventional underground mining methods. The deposit varies in depth down to a level of 270 metres and in parts to 300 metres. Currently, work is believed to have been carried down to the 240 metre level.

In the early days of the company's operation, production of copper by the cementation process accounted for a substantial part of the output. Subsequently, with the increasing expansion of the chemical industries of Western

Europe, over 2 million tons of "washed pyrites" were shipped for calcination in the then newly developed mechanical furnaces. The San Domingos mine attained peak output at the turn of the century, when about 400,000 t.p.a. crude ore were extracted. Present ore production amounts to about 160,000 t.p.a. pyrites, having fluctuated during the past six years between this level and 190,000 tons. About two-thirds of the company's production is shipped in crude form to acid plants, 70 - 80% of deliveries being directed to domestic consumers, and about 20 - 30% being exported to the British Isles and Western Europe. The balance of the production is being consumed at the mine for the production of elemental sulphur by the Orkla process.

The plant installed by the company in 1934 is based on the combination of pyritic smelting in a modified copper blast furnace, and the reduction of sulphur dioxide by coke, yielding low grade copper matte, which is re-smelted and then converted to blister copper and sulphur vapour, which, after cooling to liquid state, is purified of arsenic contamination, filtered, and left to solidify. The plant is understood to have an annual throughput capacity of 70,000 tons pyrites, permitting the production of about 17,000 tons elemental sulphur. The present annual elemental sulphur production is at a rate of about 16,000 tons; the entire output is disposed of to domestic users.

Deliveries of pyrites, sulphur and other products arising at San Domingos are effected through the company's own port of Pomaron, which is linked to the mine, 11 miles distant, by a narrow gauge railway also owned by the company. The port of Pomaron on the River Guadiana - 30 miles from the mouth of the river - is served by sea-going vessels of up to 2,000 tons.

Societe Belge des Mines d'Aljustrel

The Aljustrel mine has been in possession of the company since 1899. In the early years, exploitation was somewhat irregular and was primarily concerned with copper production from ore in the richly mineralised upper levels of the deposit. As at San Domingos, there is evidence at

Aljustrel of Phoenician and Roman pyrites smelting. The mine consists of two deposits about one mile apart. Algares is about 1,100 metres long and consists of two pyritic bands 2 - 20 metres wide, separated by carbonaceous, copper-bearing schists. San Joao is a pyritic lens 260 metres long and about 50 metres wide. Pyrites mining essentially for their sulphur content has been effected regularly since 1925, but productionfor many years remained comparatively low. Sizeable mine developments were undertaken after the war, and the first stages were successfully completed about three years ago. As parts of the deposit consist of pyrites with high base-metal content, selective mining is practised to some extent. The crude ore averaging 46½% sulphur is shipped after crushing, without the need for further ore dressing. The capacity of the Aljustrel mine has been raised to 300,000 - 350,000 tons pyrites per annum, but currently production is about 260,000 tons, having fluctuated between 240,000 - 295,000 tons during the past six years.

Successful geological prospecting between the two main ore bodies has disclosed additional potential reserves which are calculated to secure the company's continued output for some years to come. The effective rate of production is, therefore, no longer a mining problem, but a matter to be determined by the Government policy in the light of demand. In view of increasing domestic pyrites requirements, the company's deliveries to the home market have progressively increased during the past years and now account for about 20% of total deliveries, the balance being destined to acid plants in Western Europe, notably in Belgium, where the company has close connections with a leading acid and fertliser producer.

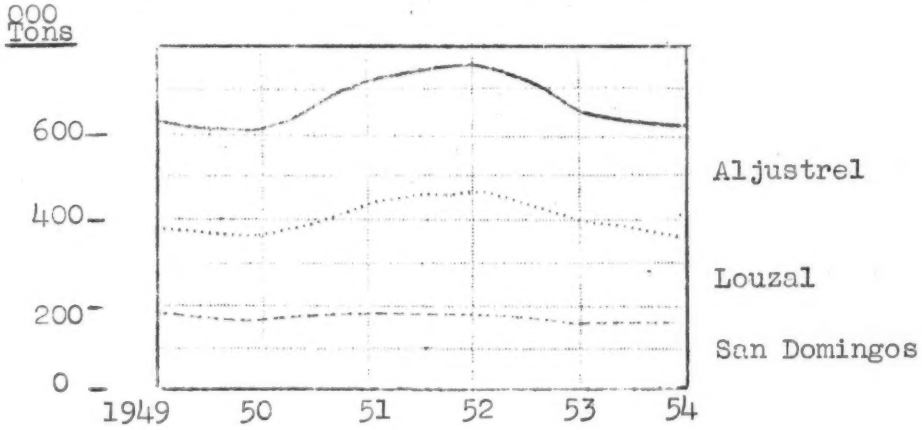
The mine is linked by the company's railway to the state railway 20 miles distant, whence ore continues by rail 110 miles to the port of Setubal in the Tagus estuary.

Mines et Industrie, S.A.

Formed in 1936, the company operates the pyrites deposits of Louzal and Serra de Caveira. The Louzal deposit consists of six concessions covering an area of about 730 acres. The pyrites occur in massive form

encased in argillaceous copper impregnated schists. The mine has been completely modernised during the past five years, and is understood to have a productive capacity of about 300,000 t.p.a. pyrites. The crude ore contains 47 - 49% sulphur and about 1% copper. 1954 production amounted to about 200,000 t.p.a. pyrites, having fluctuated over the past five years between this level and 276,000 tons. Of the company's present output, about one-fifth is destined for the home market, the balance being exported. Mine deliveries are transported by rail to the port of Setubal, which is about 60 miles distant. The company's Caveira mine, though fully developed, is not at present producing. It is believed to have an annual capacity of 100,000 tons pyrites.

The following graph indicates pyrites production in Portugal during the period 1949 - 1954:-




## Consumption

The consumption of sulphur in all forms in 1953 amounted to about 90,000 tons. Of this tonnage about 21,000 tons were in the form of elemental sulphur, the domestic supplies having been augmented by imports from Germany and Italy, totalling 4,500 tons. The bulk of regular sulphur consumption is used for agricultural purposes, notably in viticulture, and up to 2,000 t.p.a. are consumed by the textile industry. Sulphur consumed

for sulphuric acid manufacture is wholly in the form of pyrites, and in 1953 amounted to about 69,000 tons of sulphur in pyrites. Plans supported by the Government for the expansion of domestic fertiliser production, notably ammonium sulphate, foreshadow increasing pyrites requirements. There is at present no definite indication when these plans will come to fruition, nor is it possible to assess with any degree of accuracy how rapidly expansion in other sections of the sulphur and acid using industries may take place. By 1960 an annual sulphur requirement of up to 200,000 tons is predicted in some quarters, who estimate that pyrites for acid production contributing to this total may amount to over 360,000 tons.

Sulphuric Acid

Production of sulphuric acid during the period 1948 - 1954 was as follows:-

| | Metric tons 100% $H_2SO_4$ | % 50-53°Be | % 65°Be | % Other |
|---|---|---|---|---|
| 1948 | 132,000 | NO DATA | | |
| 1949 | 139,000 | 97¾ | 2¼ | - |
| 1950 | 146,000 | 97 | 1½ | 1½ |
| 1951 | 192,000 | 94¼ | 5¾ | + |
| 1952 | 183,000 | 83½ | 16½ | + |
| 1953 | 196,000 | 75 | 25 | + |

\+ less than ¼%

The largest producer of acid is Comparia Unaio Fabril of Lisbon. This old established enterprise is the largest producer of fertilisers and is also engaged in the manufacture of a wide range of chemicals, metals and textiles. The company's sulphuric acid operations are effected in old chamber plants, and a recently built contact acid plant. Most of the output is captive and consumed for the production of ordinary and triple superphosphate, ammonium sulphate, copper sulphate and other uses. The superphosphate production of this company accounts for over 60% of Portuguese production which is, at present, about 360,000 - 380,000 t.p.a.

S.A. de Produits et Engrais Chimiques du Portugal S.A.P.E.C. at Setubal, a company closely associated with Mines et Industries, S.A. accounts, at present, for about one-third of Portugal's superphosphate output. The company's consumption of pyrites is currently about 35,000 - 40,000 t.p.a., but it is understood that expansion of acid capacity may raise requirements to 70,000 t.p.a. in the near future.

Cia. Industrial Portuguesa, S.A., though considerably smaller, also contributes to Portuguese acid output.

As the result of Government plans for the expansion of the nitrogenous fertiliser industry, which were promulgated in July 1954, a substantial increase of sulphuric acid requirements for ammonium sulphate production may be expected. The need for expansion is occasioned by the present high level of imports, which account for more than 50% of Portuguese ammonium sulphate consumption.

Cia. Unaio Fabril, Alferraredo have, at present, an annual production capacity of 35,000 tons ammonium sulphate, which is to be raised to 70,000 tons. The plant of Ammoniaco Portugues at Estarreja, near Oporto, is to be extended from 25,000 tons to 70,000 tons ammonium sulphate. The cost of these two schemes is estimated at the equivalent of £8½ million.

Trade and Prices

The supply of Portuguese pyrites to the acid/fertiliser industry of Western Europe and the British Isles became increasingly important in the late thirties, when France was unable to obtain Spanish pyrites, and more so since the end of the war when increasing Portuguese exports filled the gap caused by the reduction of Spanish and Scandinavian production and exports. + As the result of the Portuguese Government's restriction on pyrites exports, the tonnage so delivered in 1953 amounted to only about 305,000 tons pyrites, 25% less than in 1952 and little more than half the peak exports in 1951.

+ For full details see Statistical Appendix

In 1953 the largest consumer of Portuguese pyrites was Belgium, although traditionally France has in the past taken the largest share of Portuguese exports, usually about 40%. Western Germany and Holland are also important export destinations, whereas Eire, United Kingdom and North Africa account for lesser tonnages. Pyrites exports in 1953 were valued at Esc. 385 (£4. 165) per metric ton f.o.b. The current domestic price is nearly 40% lower as a result of Government controls. Similarly the domestic price of elemental sulphur is controlled and is believed to be comparable with current world prices.

Esc 240

Residues

Whereas up to 1952 Portuguese pyrites consumers had been obliged to accumulate stocks of residues, the availability of an outlet in Western Germany permitted the disposal of nearly one-half million tons during 1952 and 1953. During the current year exports are negligible and pyrites consumers are once more unable to realise the metal value of their raw material. It has been mooted that with increased domestic pyrites consumption the Portuguese Government are considering the erection of a cinders treatment plant in Portugal.

Conclusion

The contribution of the sulphur industry of Portugal, to sulphur supplies of the Free World, though not large, is of significant importance as the acid industry of Western Europe, notably that of France and Belgium, relies to a considerable extent on pyrites supplies from this source. The favourable indications of geophysical surveys of pyrites reserves hold promise of a relaxation in export restrictions which may permit the modernised mines to make full use of their available production capacities. This might not only permit adequate supplies to meet the growing domestic pyrites consumption, but also facilitate the resumption of exports at levels achieved in recent years. In this connection it should, however, be borne in mind that by comparison with world price levels of brimstone, Portuguese pyrites, like those of other European producers, are expensive and that, provided the

potential sources of elemental sulphur now under active development are realised, the expansion of pyrites usage, so pronounced during the past five years, may be halted if not reversed. If this were to take place, the growing domestic market may be more welcome than it appears today.

## PRICES AND TRENDS

The increases in the delivered cost of sulphur which, during the past 3 months, have affected practically all consumers throughout the world, resulted wholly from the strong upward movement of shipping freights. F.o.b. prices of sulphur have remained unchanged and have even shown a decrease, in the case of some sales where the increased sea freight would otherwise have priced producers out of the market. Prices of United States producers have not been affected by the easy conditions in domestic and foreign markets, and there are no indications so far of a realignment of domestic and export prices.

Offers from Mexican producers continue to reach consumers throughout the world at levels comparable with U.S. prices. Indeed, one producer, Mexican Gulf Sulphur Company, guarantees price parity on a delivered basis. Mexican sulphur also appears to be competitive at U.S. East and West coast ports, as the lower U.S. domestic price is offset by the freight advantage of $1.50 - 3.50 enjoyed by Mexican shippers over tariff-bound U.S. shippers.

In Italy, a reduction of prices towards world levels is said to be imminent in view of the anticipated Government announcement in January concerning production and the disposal of sulphur stocks. In the meantime the possibility of deliveries to France under the existing trade agreement at about 27,000 lire (£15$\frac{5}{8}$) is said to be under consideration.

The price of Chilean sulphur on world markets has been under pressure, partly due to lack of interest and latterly due to the rise in freights. In recent weeks a sale for export to Western Germany of about 7,000 tons was reported

at U.S. $23 per metric ton f.o.b., and 3,000 tons are re-reported to have been shipped at the ruling Conference rate of 92s. 6d.

Offers by Japanese producers to India and Australia are reported to have been made at levels comparable with U.S. sulphur prices, though so far no acceptances are reported. Owing to the high level of activity in the German and Scandinavian pulp and rayon industries, there have been no recent offers of recovered sulphur from these sources.

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freights are based on recent quotations:-

| | f.o.b. Country of origin | Freight to U.K. + | c.i.f. U.K. |
|---|---|---|---|
| United States | U.S. $29.50-33 | 70s. | £14 - £15¼ |
| Mexico | ... | 75s. | . ditto . |
| Italy/Sicily | L.27,000/L.44,000 | 57s. 6d. | £18½/£28½ |
| Chile | U.S. $23 | ≠ 92s. 6d./110s. | £12⅞ / £13¾ |
| Japan | U.S. $38 ø | 97s. 6d. | £18½ |
| Ecuador | U.S. $40 | 92s. 6d. | £19⅛ |
| Canada | $20 ex works | 97s. 6d. | £19¼ |

≠ Conference freight.

ø Calculated on basis of earlier offers to Australis and India.

+ Based on bulk cargoes of 5,000 - 6,000 tons on the usual sulphur terms of chartering

The immediate outlook for sulphur prices is unchanged and it is thought improbable that a significant reduction of Mexican sulphur prices will occur unless by mid-1955 producers' inability to gain substantial marketing outlets would

lead to large stock accumulations, and this to a shortage of liquid funds.

No change is reported in the level of European pyrites prices, which for delivery in 1955 are understood to range from about £4. 15s. - £5. 5s. per metric ton f.o.b., basis 48% sulphur. Concumers' earlier dissatisfaction regarding prices, notably as the result of substantially reduced proceeds from residues, compared with previous years, is reported to be somewhat alleviated by a moderate improvement in the prices paid by German cinder treatment plants.

Supply

The impact of peak output in the U.S.A. during 1954 of native and recovered sulphur, estimated at about 5.8 million tons, on world supplies, has made the overall position easy. In a recent statement reviewing the end of the year position of the industry, Mr. Charles A Wight, Chairman of the Executive Committee of the Freeport Sulphur Company, stated: "Productive capacity is now at an all time high. It is ample to meet all demands of consumers here and abroad". In recent months upturn of industrial activity in the U.S.A., in particular the increase of the steel rate from 63% in August to nearly 80% in December, has resulted in a notable improvement of domestic sulphur demand. The efforts of U.S. producers to improve foreign sales during 1954 were successful, and it is estimated that over 1½ million tons, the highest on record, was exported.

In Mexico both active producers are taking steps aimed at increasing output towards their production targets of 200,000 and 400,000 tons of sulphur a year, respectively. By the end of 1954, stocks of over 80,000 tons are reported to have been built up, and both companies expect to complete their loading facilities, to permit the start of export shipments in January. The third Frasch sulphur producer, Gulf Sulphur Corporation, is reported to be making satisfactory progress at Las Salinas, where steaming of the dome is due to start in mid-summer.

So far, despite an active campaign throughout the world, there are as yet no indications of major disposals, although sales of a few thousand tons are reported to have taken place both for home and export delivery.

Following the temporary decline of sulphur output in Italy during July and August, production during the latter months of the year has again risen to about 22,000 tons per month. In the absence of export outlets the surplus of production over domestic requirements has caused the stock pile to increase to over 300,000 tons.

Production in Chile continues to stagnate in view of the absence of major export facilities, and it is thought unlikely that annual output will have exceeded 30,000 tons.

Supplies during the first half of 1955 promise to be adequate in spite of the expected substantial increase in U.S. domestic demand. Productive capacity in the U.S.A. is expected to be augmented by the start of operations at Freeport's Chacahula dome, and exploration and developments at seven other smaller domes may before long give an indication of their potentialities.

## UNITED STATES SULPHUR

### Native Sulphur

Production of Frasch sulphur during the third quarter, 1954, amounted to 1,372,936 tons, an increase of ½% over that of the preceding quarter, and of 6½% over the corresponding period of 1953. By end September, production totalling 4,116,876 tons had succeeded that of the corresponding 9 month period of 1953 by about 200,000 tons (5%).

Apparent sales during the third quarter amounted to 1,346,043 tons, 4% less than during the preceding quarter. Although this tonnage was nearly 200,000 tons (17%) greater than that sold during the corresponding period of 1953, a comparison would be misleading, as the market was then much depressed following earlier heavy purchases prior to the price rise of 1st June, 1953. Up to the end of September apparent sales totalled 3,909,955 tons, a decrease of ½% compared with the same period of 1953. Whereas export deliveries had increased nearly 265,000 tons (28½%) to 1,888,651 tons, apparent sales to the home market decreased by over 280,000 tons (9¼%). This is mainly attributed to a seasonal decline in home consumption, the reluctance of consumers to

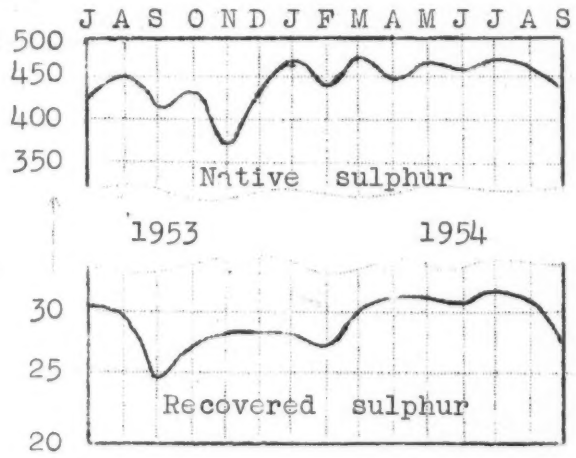
build up works stocks while supplies were readily available, and an unusual drive on the export market.

During the third quarter stocks fluctuated considerably but showed a net increase of about 27,000 tons to 3,229,407 tons, an increase of nearly 207,000 tons during the first 9 months of 1954.

Recovered Sulphur

Production of sulphur recovered from natural and oil refinery gases during the third quarter of 1954 amounted to 89,800 tons, which was 2,700 tons (3%) less than during the preceding quarter, but 5,000 tons (6½%) more than during the third quarter of 1953. Seasonal demand raised apparent sales to 119,042 tons, the highest on record. This tonnage was 22% higher than sales during the preceding quarter, and 28% higher than those during the corresponding period of 1953. Stocks at the end of September showed a consequent reduction of 29,000 tons to 97,333 tons.

MONTHLY PRODUCTION FIGURES 1953 to 1954




Salient points of the developments in the U.S. sulphur industry during the first 9 months of 1954, with special reference to the third quarter results, are as follows:-

(a) Whereas production of native and recovered sulphur during the first 9 months of 1954, totalling 4,384,176 tons, was the highest on record, monthly output figures during the third quarter declined slightly, though progressively, due, it is thought, to a desire on the part of producers to align output to anticipated demand.

(b) The unprecedented high export tonnage of close on 1.2 million tons compensated for appreciably reduced deliveries to domestic users, and total apparent sales of native and recovered sulphur amounting to 4,187,266 tons actually exceeded those effected in the same period of 1953 by about ¾%. Apparent sales in September of nearly 535,000 tons indicate, side by side with the highest monthly export tonnage on record (180,000 tons), a slight improvement of home market deliveries.

(c) Stocks of native and recovered sulphur at the end of September totalled 3,326,740, an increase during 9 months of about 197,000 tons, and representing 10 months stocks at present rates of apparent domestic consumption.

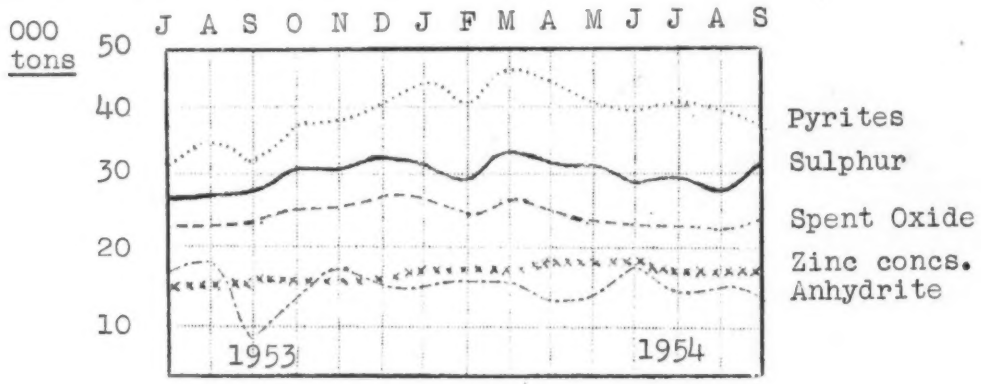
## UNITED KINGDOM SULPHUR

Consumption of sulphur in all forms during the third quarter of 1954 amounted to about 201,000 tons, or about 4% less than during the preceding quarter, but still 11% higher than during the corresponding period of 1953. It is estimated that, of the above total consumption, 34¼% was met from indigenous sources (sulphur in spent oxide, anhydrite, zinc smelter gases, and recovered from oil refinery gases), 27½% in the form of imported pyrites and 38¼% in the form of imported brimstone. Actual imports amounted to 107,949 tons of brimstone at £13 8s. 0d. per ton, and 157, 377 tons of tons of pyrites at £6 9s. 6d. per ton. As detailed on the next page, the consumption of all sulphurous raw materials was lower than during the preceding quarter.

| | 3rd Qtr 1954 | 2nd Qtr 1954 | Change+ | 3rd Qtr 1953 | Change+ |
|---|---|---|---|---|---|
| Sulphur | | | | | |
| Acid | 62,200 | 63,700 | -2½% | 57,800 | +7½% |
| Regular | 26,600 | 27,400 | -2¾% | 22,600 | +17½% |
| Total | 88,800 | 91,100 | -2½% | 80,400 | +10½% |
| Pyrites | 117,000 | 124,000 | -5½% | 96,200 | +21½% |
| Spent Oxide | 68,500 | 71,700 | -4½% | 69,100 | -1% |
| Zinc Con. | 50,500 | 54,000 | -6½% | 45,800 | +10¼% |
| Anhydrite | 42,600 | 43,900 | -3% | 43,400 | -1¾% |

+ Percentage figures shown indicate change between earlier periods and third quarter 1954.

Monthly consumption figures of raw materials were as follows:-




Note: Graph based on quarterly data.

## Sulphuric Acid

Production during the third quarter amounted to 489,600 tons (100% $H_2SO_4$). This output was 4½% less than during the preceding quarter, but 8¾% higher than during the corresponding period of 1953.

Acid production resulted from the use of sulphur bearing materials in the proportions shown on the opposite page:

| | 3rd Qtr 1954 % | 2nd Qtr 1954 % | 3rd Qtr 1953 % |
|---|---|---|---|
| Sulphur and $H_2S$ | 35¾ | 35 | 36½ |
| Sulphur in pyrites | 31½ | 32 | 28½ |
| Sulphur in spent oxide | 18¾ | 19 | 21 |
| Sulphur in zinc smelter gases | 8¾ | 9 | 8½ |
| Sulphur in anhydrite | 5¼ | 5 | 5½ |

During the third quarter total available acid making capacity amounted to 593,500 tons - about the same as during the preceding quarter - of which 82.5% was utilised. Contact acid production amounted to 348,700 tons, which accounted for about 71% of total acid output. Employment of sulphur burning capacity receded slightlyto about 74%, while that of pyrites roasters and spent oxide burners decreased to about 80% and 88% respectively.

Consumption of sulphuric acid amounted to 488,500 tons, or about 3¼% less than during the preceding quarter. The decline was seasonal and compared with the correspondinf period of 1953 acid consumption was 6½% greater, the principal changes by consuming industries being as follows:-

| | Tons | Increase/ Decrease % |
|---|---|---|
| Titanium oxide | +16,700 | +46 |
| Superphosphate | -15,100 | -14½ |
| Soap and detergents | + 6,200 | +83 |
| Rayon | + 5,600 | +9½ |
| Drugs and fine chemicals | + 3,500 | +103 |
| Hydrochloric acid | + 3,100 | +26½ |
| Iron pickling | + 3,000 | +14 |

Notable changes in acid comsumption, though quantitatively smaller, were recorded for bromine (+76%), plastics (+35%), paper (+23%), accumulators (-21%), agricultural purposes (-18%) and dyes (+15%).

Stocks

During the third quarter of 1954, sulphur stocks increased by 18,000 tons to 97,000 tons which, at current

rate of consumption, would meet demand for about 3 months. Stocks of pyrites increased 28,500 tons to 197,900 tons, representing over 5 months consumption at current rates. Spent oxide stocks declined further to 139,900 tons, a decrease of over 7% during the quarter.

The most significant features of sulphur development during the third quarter are:-

(a) Notwithstanding a slight reduction in the rate of total brimstone consumption, the proportion of acid sulphur used showed a further slight rise.

(b) The increase of stocks of imported sulphur occasioned by improved availability of world supplies.

The position of acid sulphur in the United Kingdom has apparently strengthened during the second and third quarters of 1954, largely due to the liberal interpretation of the regulations concerning the use of sulphur in relation to other sulphurous raw materials.

When in the autumn the full weight of anhydrite acid supplies reach the market, a reduction on the use of acid sulphur is inevitable, even if regulations controlling its use were removed. This situation is the outcome of the conversion programme which has placed imported pyrites in a dominating position, and has now created an apparent clash between the use of a desirable domestic raw material and the one which is the economically most advantageous. This condition is liable to continue until rising requirements permit capacity use of existing brimstone acid plants, or lead to the erection of new installations. Then, given the continuation of present day easy brimstone supply trends, the use of this material in preference to pyrites would undoubtedly be favoured.

## ANHYDRITE ACID PROJECTS IN THE UNITED KINGDOM

The use in the United Kingdom of anhydrite, the only indigenous sulphurous raw material for the manufacture of

sulphuric acid, dates back to 1929, when Imperial Chemical Industries Ltd., established a plant at Billingham. The process of heating an accurately proportioned mixture of calcium sulphate (gypsum or anhydrite) and materials containing carbon, silica, alumina and ferric oxide to yield sulphur dioxide gas - suitable for conversion into sulphuric acid by orthodox methods - and a high grade cement clinker had been developed in Germany during the first world war. The high capital costs involved and the need for plants to be situated near markets for acid and cement, as well as sources of cheap and homogeneous raw materials, has limited widespread application of the process and only the following plants are known to have been established.

| Location | Date | Annual Capacity (Tons 100% $H_2SO_4$) + | |
|---|---|---|---|
| Germany | | | |
| Leverkusen (West) | 1916-31 | 14,500 G & A | Pilot plant |
| Wolfen (East) | 1938-45 | 145,000 A | ≠ |
| Wolfen (East) | 1952 | 85,000 A | To be doubled by 1955 |
| France | | | |
| Miramas | 1937 | 25,000 G | |
| Austria | | | |
| Linz | 1953 | 70,000 G | To be increased to 110,000 |
| Poland | | | |
| Wizow | 1950 | 90,000 A | estimate |
| Busko Zdroi | Since 1945 | 90,000 G | estimate |
| United Kingdom | | | |
| Billingham | 1929 & 1935 | 107,000 A | |

+ Based on A - Anhydrite G - Gypsum
≠ Dismantled and re-erected in the U.S.S.R.

The expansion and conversion programme of the U.K. acid industry of 1951 provided for a significant increase

of anhydrite acid capacity in the form of three projects:-

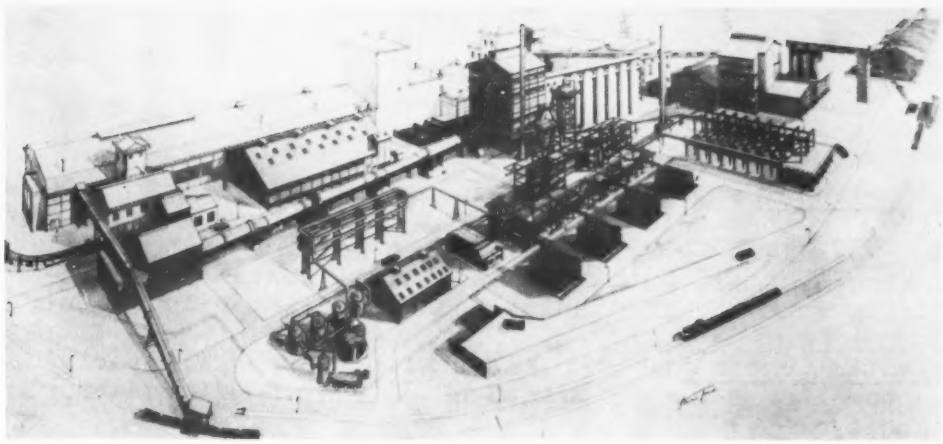
| Plant | Date | Annual Capacity (tons) | |
|---|---|---|---|
| I.C.I. Billingham | Dec. 1954 | 73,000 | A |
| United Sulphuric Acid Co. Widnes | April 1955 | 148,000 | A |
| Solway Chemicals, Whitehaven | Autumn 1955 | 90,000 | A |

The three new plants, size and differences in detail apart, are identical, and essentially employ the process and operations developed by Imperial Chemical Industries, who, in the case of the U.S.A.C. project, acted as technical advisers.

The raw materials used in addition to anhydrite are cpke, sand and shale, which, on arrival at the plant, are mechanically transported to wet storage bunkers, dried, automatically weighed to ensure a correctly proportioned feed, finely ground, mixed and deposited in raw meal silos.

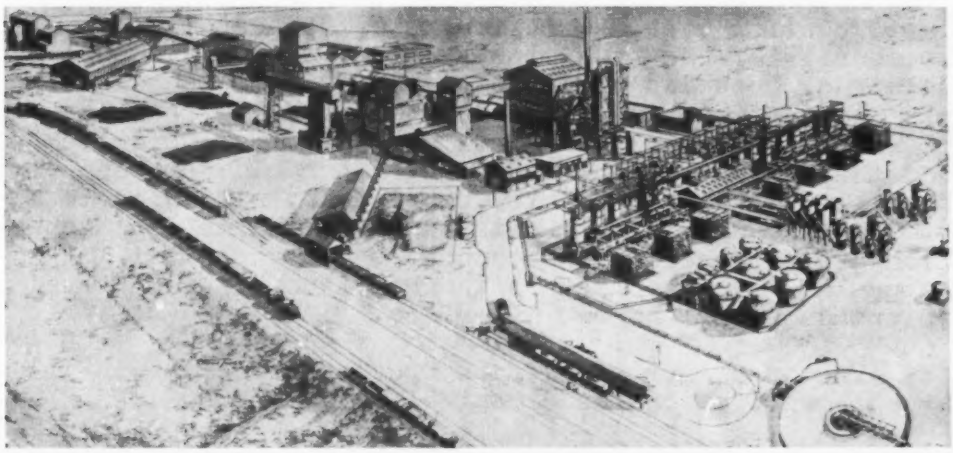
The raw meal passes through special feeding devices into the rotary kilns which are fired with pulverised coal. Contrary to the existing plant at Billingham, the kilns at the new plants are not housed. By the reduction of anhydrite with coke, sulphur dioxide is formed and silica, alumina and iron oxide combine with the resultant lime to form a cement clinker. This is cooled, crushed and mechanically conveyed to storage and then to nearby cement plants. The kiln gases containing about 9% $SO_2$ are cleaned in dust cyclones, cooled, de-misted and finally converted in standard type contact sulphuric acid plants. The approximate cost data based on experience at I.C.I. Billingham are as follows:-

| Raw material or service | Per ton 100% $H_2SO_4$ |
|---|---|
| Anhydrite | 1.66 tons |
| Coal and coke | 0.38 tons |
| Sand | 0.17 tons |
| Ash | 0.16 tons |
| Electric power | 155 KwH |
| Cooling water | 60 $m^3$ |
| Fuel (gas or oil) | 90 tonne cal. |



I.C.I. Billingham factory, showing new anhydrite kiln, with acid storage and $SO_3$ coolers in foreground

Widnes factory of United Sulphuric Acid Corporation, showing progress of construction work by October 1954



Artist's impression of Widnes factory when completed, showing, right to left, acid storage, $SO_3$ coolers, kiln feed house and kilns

Capital costs: Plants with annual capacities of 75,000 - 150,000 tons acid cost £30 - 38 per ton year $H_2SO_4$ The expenditure covers site development, services and working capital, but excludes capital costs of the anhydrite mine and of plant to convert clinker to cement.

Operating costs and comparison with other raw materials per ton 100% $H_2SO_4$ in plants of 60 - 70,000 tons annual capacity:

| | Anhydrite | Brimstone | Pyrites |
|---|---|---|---|
| Raw materials | £2.2 | 5.2 | 4.7 |
| Conversion, incl. fuel | 4.1 | 1.0 | 2.2 |
| Overheads, interest and depreciation | 3.9 | 1.2 | 2.5 |
| | 10.2 | 7.4 | 9.4 |
| Less credits | 2.1 | 0.3 | 0.3 |
| Net cost | £ 8.1 | 7.1 ø | 9.1 ø |
| Capital cost per ton year | £ 34 | 9.5 | 19.5 |

In pyrites/tower plants the net cost is £0.5 - 0.75 lower, and capital cost is about £16.

I.C.I. Billingham

After a construction period of 2 years, the new plant, costing over £2 million, started operation on 20th December 1954. The new plant, which, with its ancillary buildings, occupies a 7 acre site adjoining the existing acid plant, is centred on a single kiln, 350 feet long. All raw materials are obtained locally, the anhydrite from the company's own mine at Billingham, where capacity has been raised by about 127,000 t.p.a., silica in the form of sand from nearby pits, and alumina in coke ashes, which are produced in the company's own gas plant. A feature of the new plant is the Polysius "Fluidor" system for transporting the raw materials.

The annual arising of 69,000 tons of clinker will raise the output of the cement plant by 73,000 tons.

ø Data from different sources indicate costs of £6.2 per ton brimstone acid and £8.9 per ton pyrites acid.

The acid plant, designed and erected by Simon Carves Ltd., is a standard contact plant incorporating an oleum tower. Its rated capacity is 60,000 t.p.a. $SO_3$, which will raise potential acid output at Billingham to 180,000 tons (100% $H_2SO_4$). The new acid output will be used for by-product sulphate of ammonium manufacture in the north-east area, for plastic and synthetic fibre intermediates at adjacent Divisions of I.C.I. and for titania manufacture by British Titan Products, Ltd.

United Sulphuric Acid Company Ltd., Widnes

This £5 million project, sponsored by eleven major acid users, is due to start production in April. Construction of the plant, which occupies a 66 acre site, was started in March 1953, and is being carried out by Simon Carves Ltd.

The anhydrite requirements, estimated at 240,000 t.p.a. will be supplied by rail by British Plaster Board (Holdings) Ltd., from their Long Meg Mine in Cumberland, which was specially developed for this purpose. The outfall of clinker of 132,000 t.p.a. will be taken up by Associated Portland Cement Manufacturers for use at a new cement plant, which they are erecting adjacent to U.S.A.C's plant.

The roasting plant comprises two kilns, 350 feet long; the gases from each pass through separate ancillary cleaning plants and are converted in two contact units, one of which incorporates an oleum tower. Annual acid making capacity is rated at 148,000 tons ($H_2SO_4$ 100%), and the output has been contracted by the member companies in proportion to their capital participation, at prices representing production costs plus an agreed percentage of overheads. They are:- The Alumina Co., Thos. Bolton & Sons, British Celanese, British Enka, Clayton Aniline Co, Courtaulds Ltd., J.H. Dennis & Co., Fisons Ltd., Imperial Chemical Industries, McKechnie Bros., Transparent Paper, Ltd. Provision is made for a 50% increase in plant capacity.

Solway Chemicals Ltd., Whitehaven, Cumberland

Satisfactory construction progress during 1954, despite adverse weather conditions, indicates that the

Company, in which the Government participate by the investment of Industrial and Finance Corporation, will start operation of its new anhydrite acid plant in the autumn of 1955.

The source of raw materials is the Company's own anhydrite mine at Whitehaven, where two drifts have already been pushed through the massive deposit under St. Bees Head for more than half a mile, shale from the Company's quarry adjacent to the plant, and coke, the only material not available locally, will be drawn from Scotland.

The plant consists of two kilns, each 240 feet long, and the gases, after being cleaned, pass to a contact acid plant designed conventionally but in two sections, either being able to deal with a gas stream from either kiln. The annual capacity of the acid plant is stated to be 90,000 tons, and about one half of the output will be taken up by the Company's associates, Marchon Products Ltd., the balance being available as oleum or 96% acid to consumers within economic radius. The output of cement clinker is expected to be absorbed by the local market. There is provision to double the plant capacity, should requirements warrant it.

The additional plant capacity of anhydrite acid is expected to raise production from this source from about 100,000 tons acid in 1954, representing about 5% of total U.K. output, to about 270,000 tons, or 12½% in 1955, and to over 400,000 tons or 19% in 1956.

As an indigenous product, reserves of which are virtually unlimited, the increased use of anhydrite in acid manufacture is desirable, not only as a means to reducing the country's dependence on imported sulphurous raw materials, but also since it permits the production of cheaper acid than pyrites, which at present account for the largest item in the country's sulphur import bill. Except for its domestic availability, anhydrite is still at a disadvantage compared with the use of elemental sulphur. The possibility of further large scale expansion of anhydrite acid facilities in the future may be circumscribed by the substantial coal and coke requirements of the process, and the need to site new plants in relation to acid and cement markets.

## SULPHUR IN ITALY

In the absence of any significant developments in the Italian sulphur industry in the past three months, the critical situation remains unchanged. The special production subsidy of Lire. 6,000 - 8,000 per ton of sulphur in addition to the advance of about Lire. 36,500 per ton of gialla superiore received by producers, on delivering sulphur to Ente Zolfi Italiani warehouses, is enabling them to meet wages and operating expenses. As a result, output has again risen to 22,000 - 23,000 tons of sulphur per month in October and November, after having been substantially reduced during July and August. During the period July to November 1954, 89,400 tons of sulphur were produced, and this tonnage, although about 10% less than during the corresponding period of 1953, substantially exceeds domestic requirements. Due to excessive prices, Italian sulphur remains unsaleable in world markets, and the additions to the stockpile are now reported to have increased the tonnage so available to over 300,000 tons. Currently, Italian sulphur is offered at about Lire. 44,000 per metric ton, f.o.b. (£25½), but sales negotiations with France in 1955 are under consideration at a level of Lire. 27,000 per ton f.o.b. (£15⅝). The sale in September 1954* of 30,000 - 50,000 tons of sulphur to France at world market prices does not appear to have been realised.

The E.Z.I. programme for technical improvements is making slow progress in what appears to be a policy of gaining time. The ore flotation plants at two of the largest mines, Cozzo-disi and Valsalso, are now in operation, but the majority of the smaller undertakings who had proposed modernisation of underground and surface installations, in respect of which they had applied for grants, appear to await Government guidance.

In recent weeks, frequent meetings are reported to have taken place between the Minister of Industry, Sgr. Villabruna, the Under Secretaries of the Treasury, the Vice President of the Sicilian Region, Sgr. La Loggia, the Assessor for Industry, Sgr. Bianco and Avv. Castelletti of E.Z.I., with the object of preparing

* reported in Bulletin No.6

draft Bills designed to assist the Italian sulphur industry financially, and to finance accumulated sulphur stocks.

One of the Bills proposes to raise from 9 to 12 billion Lire (£5⅛m. to £6⅞m.) the loan funds set aside by the 1951 Law, and to make the latter more widely operative by applying a Regional Act of 2nd. August 1954, under which the Sicilian Regional Government offers to guarantee the Central Government loans taken up by mine-owners. The existing stringent guarantee requirements have resulted in less than 3½ billion Lire being taken up for approved modernisation schemes.

It is mooted that if the Council of Ministers give their assent in January, the presentation and approval of the draft Bills by the Senate and the House of Representatives may not be long delayed.

It will be recollected that proposals of this nature have been under discussion for more than 12 months, and the apparent lack of urgency on the part of the Central Government to present the Bills, which are to relieve the tension on the industry, does not encourage expectations of early results.

In the meantime, the closing down of some of the uneconomic mines is being undertaken with great circumspection in order to avoid antagonising the labour unions and to prevent widespread labout unrest. This attitude is undoubtedly influenced by the sit-down strike at the Ciavalota Mine, near Agrigento, which was only settled early in December after lasting 135 days, during which time 210 Sicilian miners stayed underground.

While the established sulphur industry faces seemingly insoluble problems, the hope is expressed in some quarters that the investigations in Sicily by the Texas Gulf Sulphur Company may lead to new developments permitting economic production. At present Texas Gulf are reported to be negotiating with the Sicilian Regional Government for a large concession where the company propose to carry out extensive geological surveys.

## NEW SOLVENT RECOVERY PROCESS

A process of recovery of elemental sulphur from low grade ores has recently been developed by the Scientific Design Company Inc., of New York. Modified from a process (Nagelvoort), originally developed by the Minapaten Company of New York, it is based on the use of carbon disulphide as a solvent.

Full details of the process are not yet available. As will be seen on the flow sheet, on page 55, the three main steps - putting the solvent into contact with the crushed ore, separating the gangue from the rich solution, and separating the solvent and the sulphur product - are designed to operate continuously.

The sulphur product is discharged as a pure molten stream of low viscosity, and is pumped into flaker, tank car or bulk storage. The filtering step, which removes the fine tailings, is only necessary if the ore contains pumice or other fine material which settles slowly. The twin filters ensure continuity of flow.

The Company, who say their production costs are "competitive with Frasch sulphur", claim that, wherever adequate sulphur deposits exist, ores with a sulphur content of as little as 10% can be economically processed, and that sulphur recoveries of more than 98% have been achieved, using ore containing 40% sulphur.

Only about 1% by weight of sulphur produced is said to be consumed in the process, in the form of carbon disulphide. The Company state that, in addition to supervisory personnel, and staff engaged on ancillary duties, the actual operation of a small plant can be performed by one man at a time, though more operators would be needed for a larger plant.

A small plant of about 30 tons daily capacity has been built in Argentina, on the basis of the original Minapaten process. According to the Company's Vice-President, Dr. R. Landau, a large plant, based on American production methods, is at present being designed by them. It is believed that it is to be installed on the West Coast of the United States.

## CURRENT EVENTS

### Australia

Sulphur Bounty

Following an enquiry into the desirability of paying a bounty on sulphuric acid produced from Australian raw materials, the Tariff Board's report has been completed and tabled in Parliament. A Bill to implement most of their recommendations has already received Royal Assent.

Among important factors taken into account were the conclusions of the Paley Report of 1952 and the International Materials Conference long range survey of world sulphur, although the somewhat pessimistic forecasts then given by these two authorities do not now seem likely to be entirely fulfilled. Undoubtedly the major factor to influence the Board's recommendations is the Government policy of reducing Australia's dependence on imported brimstone. The main features of the Board's recommendations are as follows:-

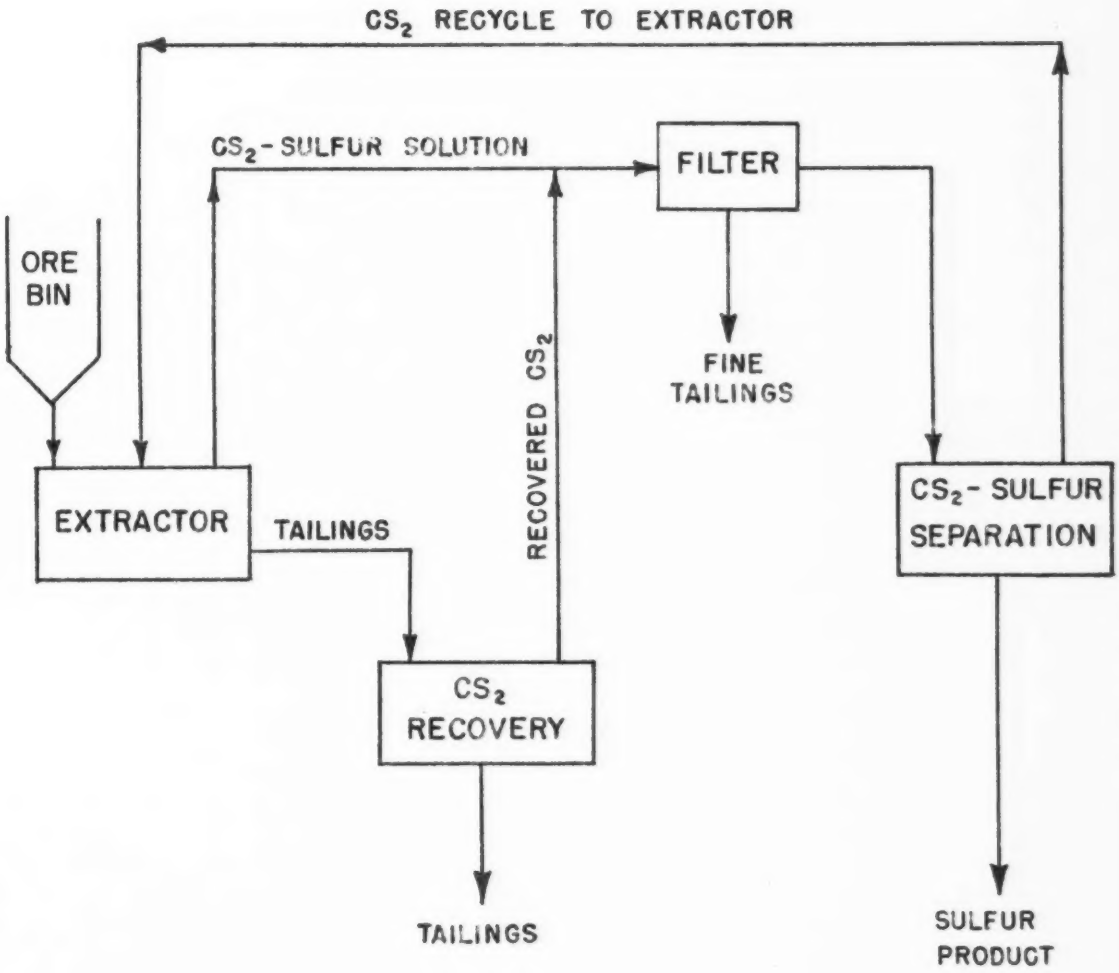
(a) That a bounty not exceeding a total of £A 600,000 in any one year be paid on sulphuric acid produced in Australia from Australian sulphur bearing materials during 5 years commencing 1st July 1954.

(b) That the bounty shall be at a rate equivalent to £A2 per ton of 100% sulphuric acid when landed duty-free cost of brimstone is £A 20. 10s. per ton; with provision for:

(i) the rate of bounty to rise or fall by the equivalent of 1s. 9d. per ton of acid for each 5s. by which the cost of brimstone is below or above £A20. 10s. per ton.

(ii) Bounty not to exceed the equivalent of £A4 per ton and to cease when the cost of imported brimstone is £A25. 10s. per ton or higher.

(Continued on p.56)




MINAPATEN - SCIENTIFIC DESIGN CO.
SULFUR RECOVERY PROCESS

(continued from p. 54) 

## Canada

### Potential Sulphur Recovery from Gas Washing Process

A method of gas scrubbing, at present being tested by the Shell Oil Company of Calgary, Alberta, in the Okotoks gas field of Southern Alberta, 20 miles south of Calgary, could, if successful, lead to a substantial yield of elemental sulphur.

In this gas field, where the gas contains about 35% hydrogen sulphide and about 10% carbon dioxide, the Company have been experimenting for the last two months on a small pilot plant. Data are at present being collected on the application of water washing as a sweetening process for the sour gas. Test data on a packed column has been obtained and further tests are continuing with bubble cap column internals.

The pilot plant is for research only, and not for production. In a full scale plant, however, most of the hydrogen sulphide and carbon dioxide would be extracted, using a water wash, the rest being removed by amine solution. The acid gases from the amine solution and the water could then be converted into elemental sulphur.

## United States of America

### Duval Sulphur and Potash Company

In reply to a rumour that output at their Orchard Dome, in Fort Bend County, Texas, was declining, the Company's president has stated that they hope to continue "at the present rate of production" for a further 5 10 years.

Frasch sulphur production from Orchard Dome in 1953 amounted to 228,350 tons, and it is understood to have continued during 1954 at a rate of about 200,000 tons.

Orchard Dome came into production in 1938, and under the present Company's management has since yielded about 3.3 million tons of sulphur.

The Company have recently acquired the sulphur rights on High Island Dome, from the Stanolind Oil & Gas Company, and are now engaged in drilling exploratory wells there. Results of the drilling are authoritatively stated as not being very encouraging so far.

Standard Sulphur Company

According to a recenr statement by the Company's president, Mr. Gilbert Ebarb, Frasch sulphur production at the Company's Damon Mound plant, which has a capacity of 200 tons a day, is being maintained at a satisfactory level. The additional equipment recently installed there was scheduled to be brought into operation at the turn of the year, and an increased output of up to 200 tons a day more is expected shortly.

Meanwhile, the contract made in November 1954 with Gulf Oil Corporation and Brazos Oil and Gas Company gives the Standard Sulphur Company development rights over nearly 1,000 acres on the Allen Dome, in Brazoria County, Texas, about 25 miles west of Freeport.

24 exploratory drillings by other companies have already revealed a commercial sulphur deposit of about 1 million tons. The Standard Sulphur Company have started drilling ten production wells and they hope, in the spring, to start building a ⌀ 1½ m. plant for producing Frasch sulphur.

The new plant, which should be in full operation by the autumn, is expected to add a further 200 tons a day to the daily rate of production, bringing the total capacity of Standard Sulphur Company at both domes to about 600 tons a day.

Mexico

Mexican Gulf Sulphur Company

During his visit to London in October, Mr. Paul Nachtman, the Company's president, provided details of the developments at the Company's San Cristobal Dome and

he has since supplemented this by further information which includes some comments by Mexican consumers of San Cristobal sulphur.

Production and stocks

Regular production started on 15th March 1954, with the steaming of one well. Between that date and 18th August 1954, additional wells have been added, and since 18th August, five wells have been in production and yielded 57,000 tons by the end of 1954. The Company's sulphur stocks in vats at San Cristobal and Coatzacoalcos, Mexico - after domestic sales of 7,000 tons - at the end of 1954 were estimated to amount to 50,000tons.

Recent additional financing

In recent weeks the Company have completed arrangements for the sale of 200,000 shares of stock which they expect will realise about $2m., most of which amount will be used to increase the boiler capacity from the present 1.1m. gallons to 2.1m. gallons per day, and to equip four additional wells. These measures are expected to result in doubling present production.

Reserves

Of the Company's total concession area of 1,482 acres, only 125 acres were originally surveyed, and recoverable reserves estimated at 2,837,000 tons of sulphur. Preliminary results of a survey of an additional 25 acres indicate that the total of proved reserves may be doubled. Exploitation to date is confined to 5 wells in an area of 1.3 acres, which appear to be giving a yield 40% in excess of original estimates.

Quality

Following the reduction of the steaming temperature, output during the last quarter has proved to be lighter in colour than tonnages first produced, and it appears to be similar to the production of some of the larger U.S. domes.

Port facilities

The loading facilities in the free port area of Coatzacoalcos are now expected to be completed during the early part of January, and will permit a loading rate of 450 tons per hour into vessels up to 27' 6" draught. Being a free port, export shipments will escape the transportation tax of 2.2%.

Sales and prices

The company has appointed as sales agent in 16 countries the Associated Metals and Minerals Corporation of New York, whose associates, Leopold Lazarus Ltd., London, represent them in the United Kingdom. Sales offers abroad are being made at price levels which would permit consumers to purchase Mexican sulphur on the same delivered terms as U.S. sulphur. Over the period May to December 1954 the company made domestic sales totalling approximately 7,000 tons. This sulphur was accepted and used by various industries, including sulphuric acid makers, and producers of insecticides, steel, rubber, etc. Sales to the home market are made at controlled prices of Mexican Pesos 270 f.o.b. mine (U.S. $ 21.60) to acid makers and Pesos 350 - 406 (U.S. $ 28 - 32.48) to other users (controlled price Pesos 500 - U.S. $40).

Consumers' comments

Two prominent sulphuric acid manufacturers in Mexico, Guanos y Fertilizantes, S.A., and Industria Nacional Quimica Farmaceutica. operating Lurgi and Monsanto plants respectively, have stated that San Cristobal sulphur was satisfactorily used and produced water clear acid.

Pennsalt de Mexico, S.A., confirmed that Cristobal sulphur was found to grind more satisfactorily than other sulphur used by them previously.

Pan American Sulphur Company

This company's Jaltipan dome on the isthmus of Tehuantepec started producing on 28th September, 1954.

Shortly after this time, press reports indicated an interruption in output due to a collapse of the dome structure and consequent loss of steam. Mr. H.C. Webb, the company's president, has since provided, both privately and in a public statement, the following information. He states that during the last quarter of 1954, output amounted to 30,000 tons of sulphur, and that no unusual problems have been encountered during this initial production period. He says that by the third week of December output had reached the figure of 900 tons of sulphur a day, and since then it has been stepped up to 1,100 tons a day. The output is stated to consist of both bright and off-colour sulphur. Ultimately, according to Mr. Webb, the company propose to produce at a rate in excess of 1,500 tons a day, resulting in an annual output of 400,000 - 600,000 tons. In the light of the comprehensive surveys carried out prior to the production stage, and with the experience gained since then, the company confidently expect that no untoward difficulties may prevent the achievement of this target.

Sulphur shipments will be effected from Coatzacoalcos (Puerto, Mexico) where the company have dock space within the free port area. Rail facilities link Jaltipan with the port which is some 25 miles distant.

First deliveries to customers were scheduled to start at the end of December, and large scale regular shipments are to take place during the first quarter of 1955.

## Chile

### New Sulphur Deposit

About the end of October, 1954, a deposit of high grade sulphur was reported to have been discovered in the Julia Segunda and Casualidad areas of Chile, near the Bolivian and Argentinian borders.

In recent months, the Chilean Department of Mines and Fuels has shown much interest in modern sulphur

mining and refining methods which would permit the economic exploitation of the vast sulphur reserves of the country. In this connection, it will be recalled that the Minister has been examining the results of experiments conducted by Dr. Francesco Roma (see Bulletin No.6, p.59). Further, he is reported to be lending support, through one of the national development agencies, to the Compania Azufrera Purico, who are contemplating the installation of a large scale modern refining plant.

In the light of this, the statement by Senor Emilio Vogel, Head of the Chilean Mines and Fuels Department, that he believed the newly discovered deposit to be "of such importance that its exploitation will bring Chile to second place among world sulphur producers", may be a pointer that the Chilean Government wish to encourage measures that may lead to the establishment of a modern and economic undertaking. There are as yet no indications of the extent or quality of the deposit, nor have any plans for its exploitation been made public.

## India

### New Ore Refining process

Associated Engineers Ltd., of Calcutta, report that they have developed a new and economic process for refining crude sulphur ores. The method, which involves the use of saline solutions, is stated to produce sulphur at about £5 a ton, and the plant is said to be able to produce up to 60 tons of pure sulphur an hour. The process is believed to be arousing interest in many countries, and the company are taking steps to safeguard it by patent rights throughout the world.

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## STATISTICAL APPENDIX

### SOUTHERN RHODESIA

Pyrites Production (000s tons - approximately 44%S)

| | | | |
|---|---|---|---|
| 1946 | 24.1 | 1950 | 13.6 |
| 1947 | 16.9 | 1951 | 27.8 |
| 1948 | 13.0 | 1952 | 18.8 |
| 1949 | 16.7 | 1953 | 39.4 |

### PORTUGAL

Pyrites Production (000s metric tons)

| | | | |
|---|---|---|---|
| Av. 1900/9 | 330.2 | 1950 | 613.5 |
| " 1910/19 | 246.7 | 1951 | 729.6 |
| " 1920/29 | 246.3 | 1952 | 755.9 |
| " 1930/39 | 364.5 | 1953 | 650.7 |
| " 1940/49 | 290.0 | 1954 | 630 (Est.) |

Pyrites Exports (000s metric tons)

| | 1938 | 1950 | 1951 | 1952 | 1953 |
|---|---|---|---|---|---|
| France | 438.3 | 219.5 | 229.7 | 193.6 | 69.7 |
| Belgium | 13.6 | 134.6 | 159.1 | 96.5 | 116.6 |
| Netherlands | 15.0 | 45.6 | 56.8 | 47.3 | 45.6 |
| W. Germany | 3.0 | 83.5 | 73.1 | 38.2 | 53.6 |
| Others | 25.2 | 14.0 | 52.2 | 37.2 | 19.3 |
| | 495.1 | 497.2 | 570.9 | 412.8 | 304.8 |
| Value per metric ton | n.d. | £2/10/6 | £2/19/6 | £4/8/0 | £4/16/0 |

Elemental Sulphur (000s metric tons)

| | Production* | Consumption | Imports |
|---|---|---|---|
| Av. 1935-1948 | 10.9 (n.d.) | n.d. | 1.1 |
| 1949 | 10.5 (n.d.) | 11.0 | 0.3 |
| 1950 | 14.4 (57.5) | 12.2 | 0.3 |
| 1951 | 14.1 (60.3) | 7.5 | 0.2 |
| 1952 | 15.8 (64.5) | 12.2 | - |
| 1953 | 17.0 (70.1) | 21.0 | 4.5 |
| 1954 | 16.0 (Est.) | n.d. | n.d. |

* Figures in brackets indicate the tonnage of pyrites used in elemental sulphur production.

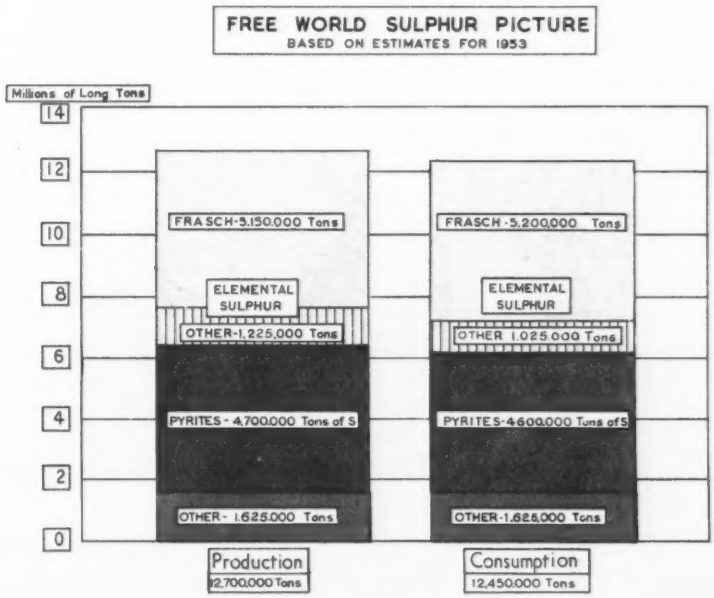
# FREE WORLD SULPHUR SURVEY

We are indebted to the FREEPORT SULPHUR COMPANY for kindly permitting the publication of this Survey of the Free-World Sulphur Production and Consumption for the year 1953. The substance of this article was originally presented by the company's Chairman of the Executive Committee - Mr. Charles A. Wight - to many leading representatives of the U.K. sulphur industry and trade and Government officials, on the occasion of a private film showing arranged in London early in July by Messrs. F.W. BERK & SONS.

The information on which the survey of production and consumption in 1953 is based originates in the main from official statistical and trade returns and the data for the summary of new production capacity has been collated from published accounts by the operating and promoting companies concerned. Since its original presentation additional information has come to hand which enabled Freeport Sulphur Company to amend the estimates of some of the production and consumption data.

## 1. Sulphur Supply and Demand

Total sulphur production in 1953 of 12.7 m. tons exceeded consumption by ¼m. Tons. The distribution of the various sulphurous raw materials that contributed to these totals is shown in Fig. I



It will be seen that whereas Frasch sulphur consumption exceeded production by 50,000 tons, total elemental sulphur production was 150,000 tons in excess of consumption. In this connection it must be recalled that Italy's export surplus of about 130,000 tons failed to find a market due to excessive price. There was an excess of 100,000 tons of production over consumption of sulphur in pyrites (including 125,000 tons sulphur in pyrites shipped to Iron Curtain countries) whereas output of sulphur from "other" sources equalled consumption.

The free-world supply and demand both as to quantity and origin are viewed as a Sulphur Pool. Whereas the developments during the sulphur crisis 1951/2 disturbed the natural balance imposed by price and geographic location, the free-world situation in 1953 shows signs that this equilibrium is righting itself. Production - the filling of the free-world Sulphur Pool - and consumption - the emptying of the free-world Sulphur Pool - are depicted in the following Figures:

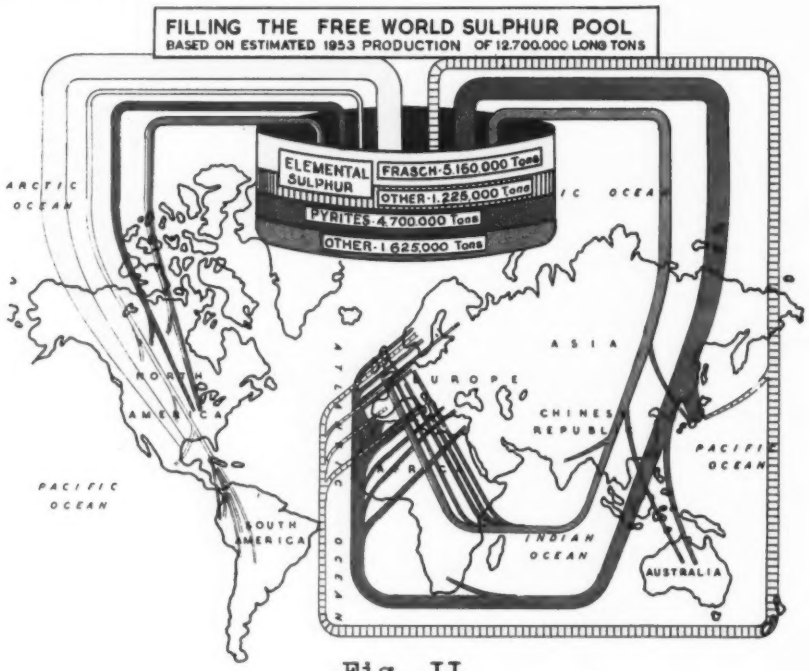
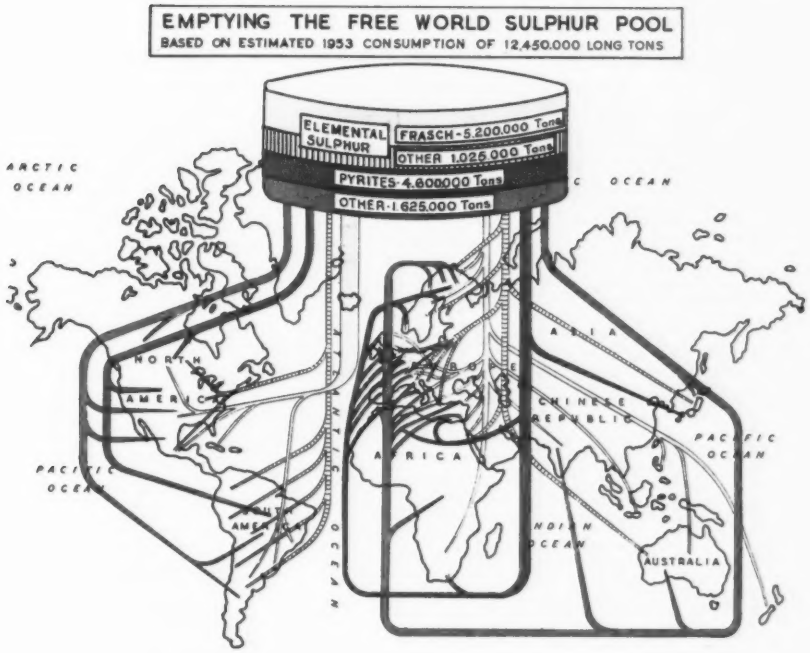



Fig. II

Fig. III

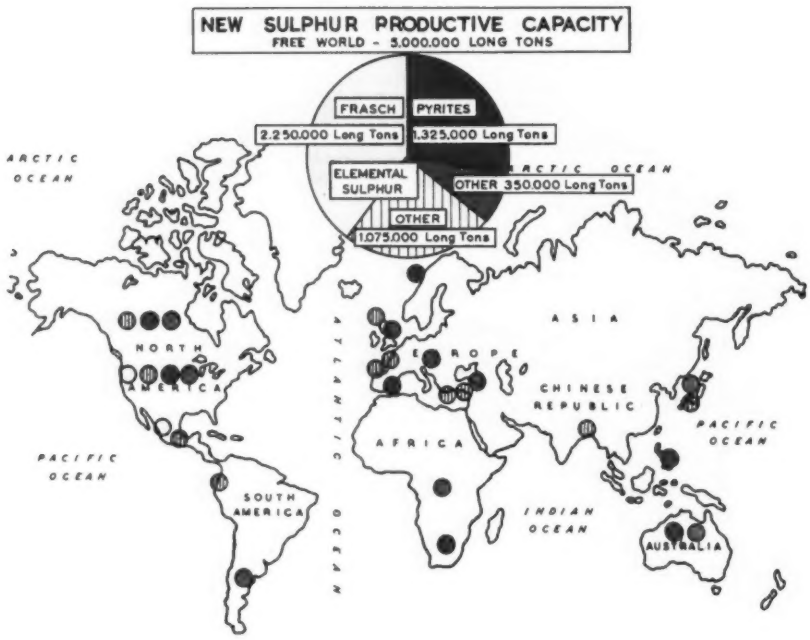



The dominating position of elemental sulphur in the western hemisphere and that of pyrites in the eastern hemisphere are clearly apparent as is the dependence of the rest of the world on U.S. Frasch sulphur supplies. The arising of other elemental sulphur, notably of recovered sulphur, on the other hand is shown to be widely distributed, and although quantitatively less extensive is of growing importance.

## 2. New Productive Capacity

Forecasts are based, as mentioned above, on the reports of operating and promoting companies, and no attempt has been made in the compilation of this summary to assess critically the possibility or probability of individual projects attaining the planned production targets. In Fig. IV, the estimated production in 1953 is shown side by side with new productive capacity which, if fulfilled, would increase the size of the present sulphur pool by nearly 40%.

Fig. IV

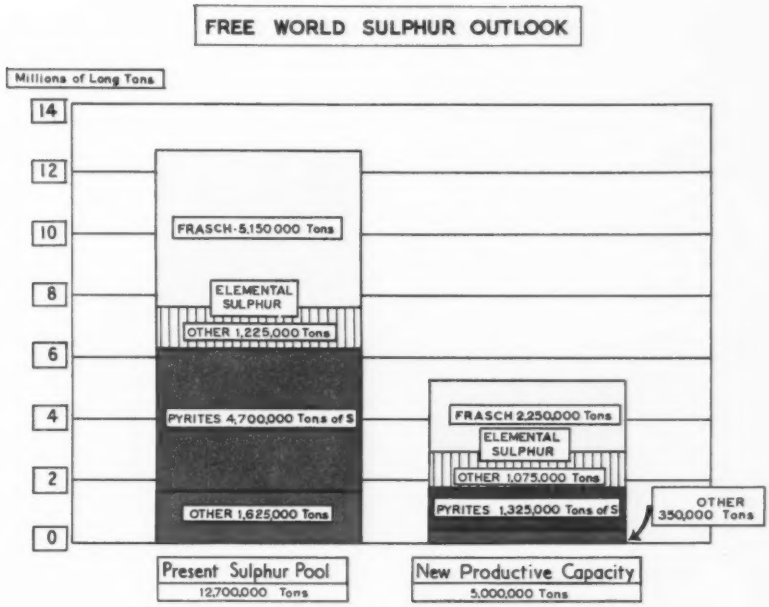



A comparison of present and projected outputs of the various sulphurous raw materials discloses the following picture:-

| | 1953 | New Capacity | Total |
|---|---|---|---|
| Tonnage | 12.7m. | 5.0m. | 17.7m. |
| Of which: | | | |
| Frasch sulphur | 40.5% | 45.0% | 41.8% |
| Other elemental sulphur | 9.7% | 21.5% | 13.0% |
| Sulphur in pyrites | 37.0% | 26.5% | 34.0% |
| Sulphur in other forms | 12.8% | 7.0% | 11.2% |

The geographical distribution of the new sources of supply is shown in Fig. V.

Fig. V.




The advent of Frasch sulphur production in Mexico widens this field of operation, and, as shown above, new sources of sulphur supplies in other forms are being developed throughout the free-world. The potential increase of sulphur supplies, in various forms, promises stable, if not competitive, marketing conditions. The development of new sources should allow the sulphur industry of the free-world the choice of materials according to individual consumers' specific needs, in the light of their countries' economies.

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